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AUGUST 1973

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solid-state
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RECEIVER

this month

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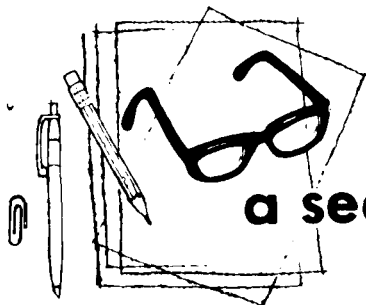
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a second look

by jim
fisk

From all indications, it looks like there's a good possibility that we're going to lose the top 1 MHz of the amateur 220-MHz band to make way for a new Citizens Radio Service. Although this new CB service was originally proposed over two years ago by the Electronic Industries Association, the wheels of government grind ever so slowly, and it wasn't until early June that the FCC released their Docket 19759, proposing the creation of a new 224-225 MHz Class-E Citizens Radio Service. Comments are invited from interested parties (the usual original and 14 copies) before September 20, 1973.

According to a spokesman at the FCC, it is estimated that the new CB service could be finally approved by the Commission within 6 months to a year. The Commission also said that the new 1-MHz Citizens Band would be divided into 40 25-kHz fm channels. Eligibility would be similar to that for the present Class-D service on 27 MHz — any person 18 years or older who meets the basic criteria for licensing.

In proposing the new band, the FCC cited the need for additional frequencies to meet the requirements of the general public for improved radio communications and to relieve some of the heavy concentration of CB stations on the channels available in the 27-MHz band — the 49,000 Class-D licensees of 1959 had grown to nearly 900,000 in 1972.

Obviously, a new radio service such as this creates a huge new market for the electronics industry, and the EIA is pushing hard for early approval. Once the necessary equipment is mass produced, it is expected to sell for about \$200 to \$300 per unit; the EIA estimates that two to three years after the new service is

started, it will represent a new electronics market amounting to some \$300 million annually. That's a lot of boodle!

Since the proposed use of a portion of the 220-225 MHz band for CB would not be in accord with the International Table of Frequency Allocations, objections from Canada and Mexico might require a prohibition against any other operations in some border areas. Until that matter is resolved, mobile stations would not be permitted to operate within ten miles of the border, and base stations would not be permitted within 25 miles of the border.

Although I'm usually an optimist, there appears to be little that amateurs can do to prevent the loss of 224-225 MHz. When a proposal reaches the FCC Docket stage, it is usually approved in one form or another. If you remember the big-bucks EIA steamroller and the nearly one-million CBers clamoring for approval, the new class-E service is practically a foregone conclusion.

However, there's a small, bright side to the picture, too. Since the industry will be geared up to mass produce 225-MHz CB radios, there should be an abundance of gear available for amateur use. 220 has always been one of our little-used bands, essentially an orphan, and the lack of proper equipment has been one of the major stumbling blocks. On the other hand, it would be a simple matter for a proficient CB technician to illegally tweak his type-accepted radio down to the amateur frequencies. Perhaps that's the price of progress.

Never-the-less, the FCC wants to hear your comments. Don't forget the 14 copies.

Jim Fisk, W1DTY
editor

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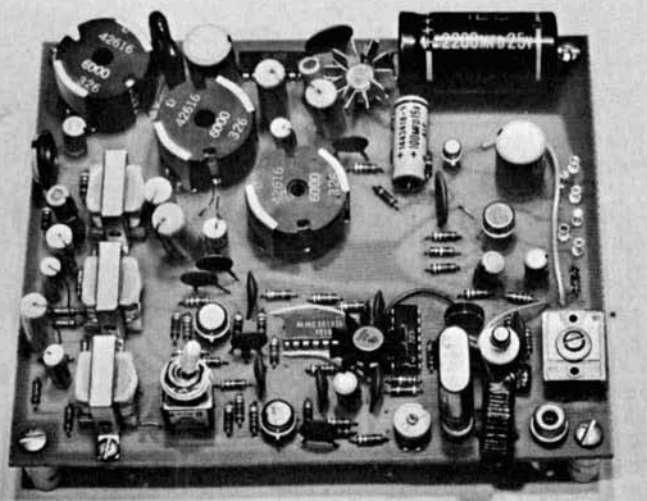
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The Phase II Receiver —
a state-of-the-art
phasing-type receiver
for high-frequency
ssb communications

G.K. Shubert, WAØJYK, 1308 Leevue Drive, Olathe, Kansas 66061

Many amateurs participate in a public service net or a public service program such as MARS, CAP, AREC or RACES. This receiver, which I call the *Phase II Receiver*, was designed to provide economical monitoring of a single net frequency while the station receiver, or transceiver, is free for general hamming. Portable and mobile operation was also considered. The power requirement is 10 to 24 volts, ac or dc, at about 180 mA. Although this is a bit high for flashlight batteries, the design concept required ICs that draw relatively high current.

Crystal-controlled operation provides excellent stability and, since fixed frequency monitoring with high stability was the object, no vfo or frequency synthesizer was included in the initial design. However, it may be added at a future date. Most commercial equipment available to amateurs does not provide the frequency coverage or the stability required for use on MARS or CAP frequencies. It's really great to turn on a cold receiver and be within 10 hertz of the exact frequency — immediately! That is what the *Phase II Receiver* will do.

Direct conversion has been used often for inexpensive receivers but the highly undesirable audio image has been a menace, particularly on crowded bands.^{1,2} Although many of these receivers have been referred to as ssb receivers, that is a complete misnomer. More accurately, they are double-sideband receivers that will copy single-sideband signals providing, of course, that there is no strong interference on the unwanted sideband. Even if there is absolutely no interference there is still a degradation of the signal-to-noise ratio because the receiver bandwidth is twice as wide as the signal.

phasing-type receivers

The phasing-type receiver or, at least, the phasing-type detector is by no means a new technique. The phasing-type transmitter, however, has retained its popularity better than the phasing-type receiver. Excellent explanations of the technique were given by Villard, Thompson and Norgaard in several post-war issues of *QST*.^{3,4} Amateur ssb was in its infancy when those articles were written, and the phasing method of receiving and transmitting was at least as popular as the filtering method — probably more so because it held an economic advantage. Perhaps it still does!

Taylor revived the phasing receiving technique in 1969 and combined phasing with direct conversion.⁵ For those of you with less extensive libraries and for those of you who understand semiconductors better than tubes, the phasing technique and direct conversion receivers were brought up to date by Ed Noll in 1971.⁶

It has been stated that a direct-conversion receiver does not provide single-signal reception.⁷ This is somewhat like saying that a Ford automobile has one-hundred horsepower — a rather senseless generalization. There are quite a few filter-type receivers around that really don't provide single-signal reception either, due to design shortcomings.

I have presented the *Phase II Receiver* and the phasing technique of receiving at

several club meetings and at two Regional Air Force MARS Conferences. It is interesting that the newcomers understand ICs, but some of the old-timers have a much better comprehension of the phasing technique.

To be competitive with receivers that use crystal or mechanical filters, the phasing-type receiver must suppress the unwanted sideband by 40 dB or more. Wade has researched the problem of

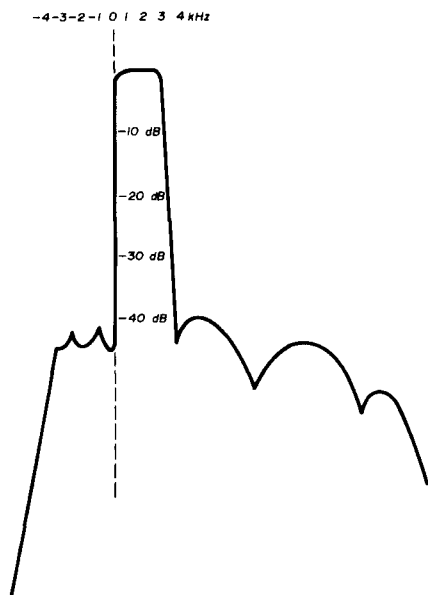


fig. 1. Passband characteristic of receiver for upper sideband reception.

unwanted sideband suppression thoroughly and provided the data in convenient form.⁸ At first glance, the infinitesimal phase and amplitude variations that can be tolerated seem formidable but, modern integrated circuits maintain the amplitude balance, a digital rf phase shifter can be quite accurate, and audio phase shift can be controlled very closely with modern computer-aided designs.

selectivity

The passband shape of a phasing-type receiver is unique. Fig. 1 shows the receiver passband for upper sideband re-

ception. Cancellation of the lower sideband occurs immediately below the suppressed-carrier frequency and the passband shape on the upper side is controlled by the audio-frequency lowpass filter. The effective passband shape factor is better than 1.2:1 at the 40-dB points. A crystal filter with skirts that steep should easily cost more than the whole *Phase II Receiver*. A bandpass filter may be substituted for the audio lowpass filter for the reception of CW or RTTY.

Taylor stated that reception with a

receiver has quite wide bandwidth. Undoubtedly, these conditions will pave the way for the future addition of a digital noise blanker.

A design goal was to provide a versatile receiver module that could function by itself or be integrated into a monitoring or transceiving system. Since the system approach was in mind, very little front-end filtering has been provided on the PC board itself. The board has been drawn to allow the mounting of volume and agc potentiometers directly on the board, but

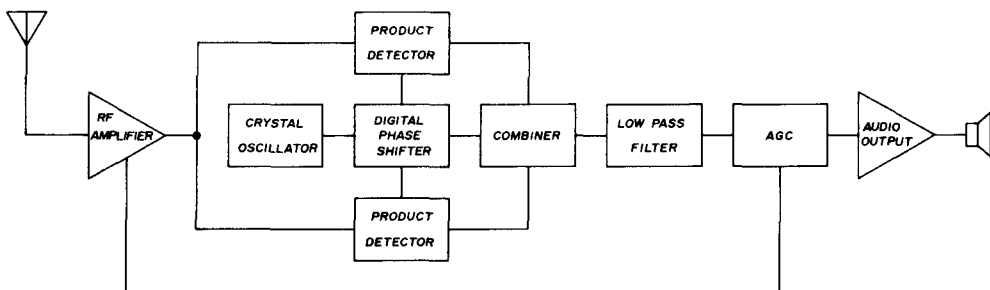


fig. 2. Block diagram of the high-performance phasing-type ssb receiver. The circuit, fig. 3, makes maximum use of integrated circuits.

direct-conversion receiver gives the signal a feeling of "transparency" or "presence."⁵ Impulse noise and atmospheric noise are less objectionable too. Crystal filters and mechanical filters have a very narrow percentage bandwidth with an accompanying high degree of delay distortion. Short pulses applied to this type of filter are severely distorted or stretched. A splendid example of this is to listen to a pulse with a wide filter (a-m type filter) and then listen to the same pulse with a very narrow filter (CW type). A pulse that only causes a click with the wide filter will result in a dull thud with the narrow filter.

The delay distortion of the audio low-pass filter, including the all-pass phase-shifter, is only a small fraction of that found in small percentage bandwidth bandpass filters. The all-pass networks used in the audio phase-shift networks provide a certain amount of time delay of the signal. The signal at this point in the

in most cases panel-mounted pots would probably be more convenient. The complete *Phase II Receiver* is on a 5x6-inch single-sided PC board which is potentially the most valuable 30 square inches of real-estate in my hamshack.*

Primary frequency coverage of the receiver as shown is from 3 to 10 MHz but this range can be extended by changing T1 or by providing a different front-end filter. Sideband suppression is poorer above 10 MHz and reception below 1 MHz may require more inductance at L1.

It is also possible to use the basic receiver for reception of vlf and low-frequency CW and RTTY transmissions. Of course, a-m reception is not very pleasant with no way to turn off the bfo,

*Printed-circuit boards for the Phase II Receiver, drilled and silver plated, are priced at \$8.00 each from CMS Products, 317 NW 82nd Street, Kansas City, Missouri 64118.

so broadcast reception doesn't offer much. Frequency measurement of a received signal is a simple matter with this receiver and more will be mentioned about this later.

rf amplifier

A dual-gate mosfet provides good *agc control and amplification over a wide frequency range with no neutralization*. The mosfet provides wide dynamic range and low cross-modulation but also requires "backward" agc voltages. The agc voltage decreases as received signal strength increases. The single tuned circuit in the front end is an absolute minimum. This single circuit may be adequate for portable operation but operating in a metropolitan area will require some additional filtering to keep out broadcast stations and other local amateurs.

The output stage of a companion-transmitter may provide enough additional filtering. If the receiver is to be used with a transmitter of fairly high power level it might be wise to place protective diodes across the front end circuit. The Motorola MFE3006 transistor is the only one I have tried in the front end but others should work as well or better. Some other transistors might be a little more rugged but my receiver hasn't blown one, even with 100 watts radiating from an adjacent dipole.

product detectors

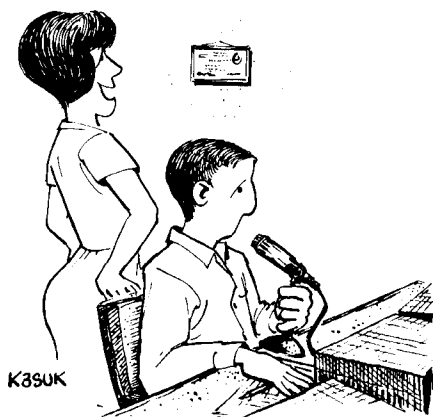
The signal from the rf amplifier is fed to a pair of identical MC1496 double-balanced mixer ICs used as product detectors. These product detectors have an extremely wide dynamic range and contribute quite a lot to the overall performance of the receiver. Transformer coupling at the outputs of the product detectors provides a low impedance to drive the audio phase-shift networks, attenuating frequencies below about 100 Hz and above 20 kHz or so. The frames of the transformers are grounded and help prevent any rf leakage from the product detectors to the audio combiner.

audio phase-shift networks

The audio phase-shift networks are a pair of four-pole, all-pass, RC networks which track each other with a very precise 90-degree phase difference.⁹ The audio phase shifters in most block diagrams are shown as plus and minus 45 degree phase shifts but, of course, this is never the case in practical networks. It is extremely important to use precision film resistors in these networks to maintain proper phase shift not only initially but to stay put for the years to come.

If portable or mobile operation is contemplated the capacitors in this section should be polycarbonate film; for hamshack use the polyester film types (Mylar) should be adequate. Capacitor tolerance is equally important as the resistor tolerance but 1% capacitors are not a stock item. Even 5% capacitors are a little hard to find. If possible, these capacitors should be bridged or measured but 5% values and a little luck will provide good sideband suppression.

Two jfets provide the audio combining and some amplification with a pot connected between the sources to trim any amplitude imbalance preceding them. The audio phase-shift networks prefer to operate from a zero impedance into an infinite impedance and are not too forgiving of any other conditions. The audio



"Hey! How about that. . . your license expired in March of 1969. . ."

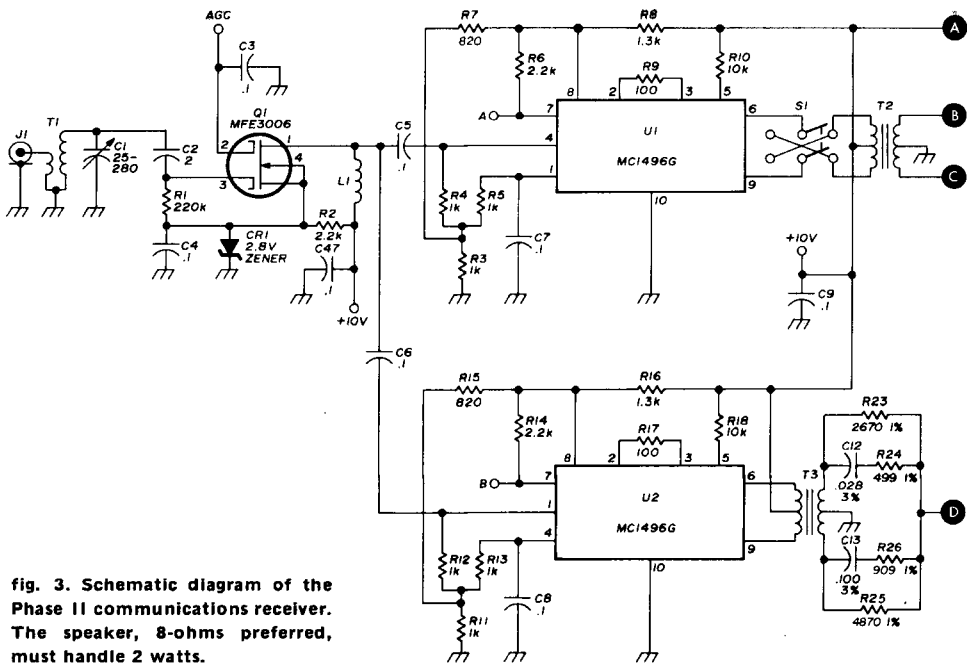


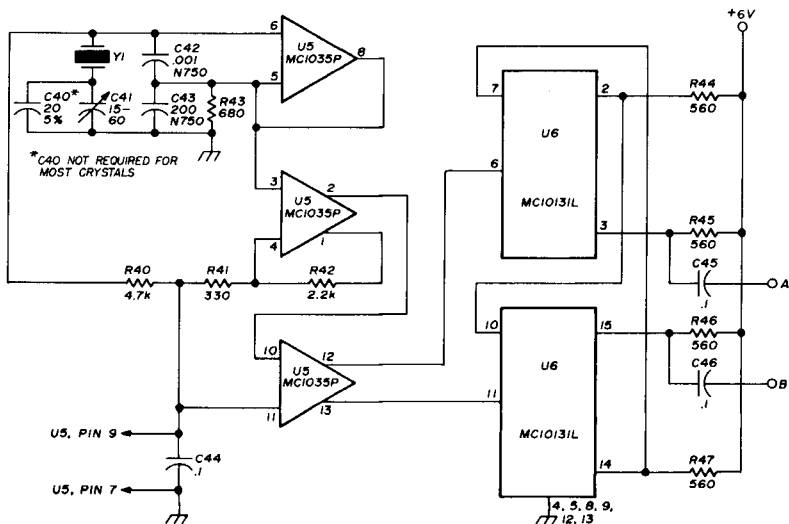
fig. 3. Schematic diagram of the Phase II communications receiver. The speaker, 8-ohms preferred, must handle 2 watts.

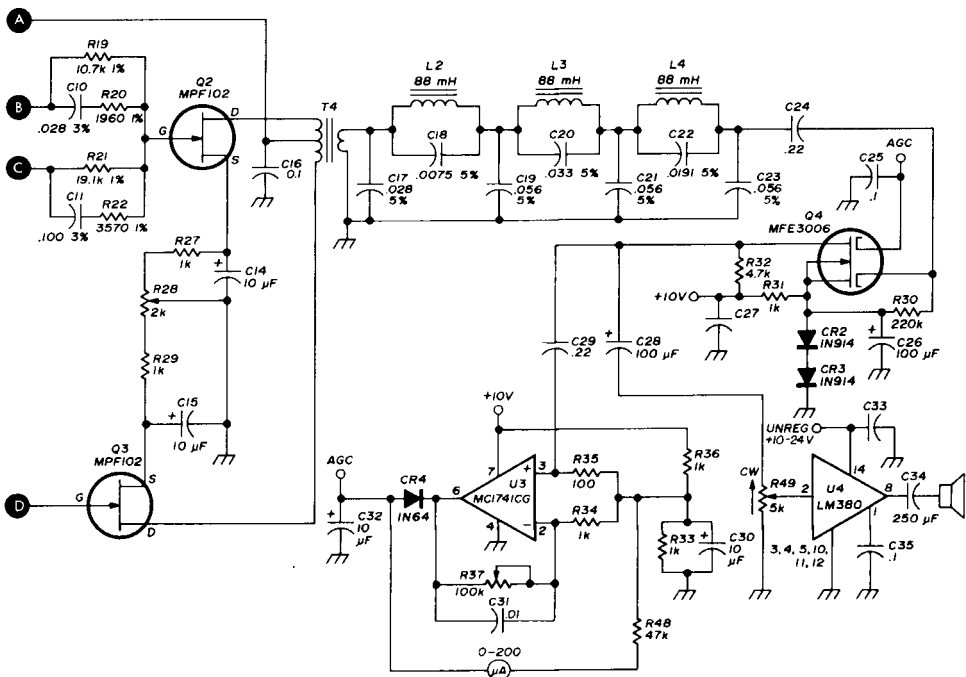
combiner uses a transformer for mixing and for impedance conversion to match the 1 kilohm input impedance of the audio lowpass filter.

audio lowpass filter

The audio lowpass filter is an elliptic

function type design providing three attenuation peaks in the stopband and a cutoff frequency of 2.8 kHz. The filter has been computer "juggled" to permit the use of surplus 88-mH loading coils while retaining the best possible performance. Several receivers I have built used





- | | | | |
|-----|--|----------|---|
| L1 | rf choke, 40 turns no. 34 on C40304TC core | R49 | 5000-ohm pot, PC mounting (Mallory MTC-53L1) |
| L2 | 88-mH toroid, tuned to 6180 Hz with C18 | S1 | PC-mounting dpdt switch (ALCO MSTA-206N) |
| L3 | 88-mH toroid, tuned to 3340 Hz with C20 | T1 | secondary, 40 turns no. 24; primary, 2 turns no. 24 on Amidon T68-6 core (for 3 - 10 MHz) |
| L4 | 88-mH toroid, tuned to 3815 with C22 | T2,T3,T4 | 3:1 miniature audio transformer* |
| R28 | 2000-ohm pot, PC mounting (Mallory MTC-23L1) | Y1 | fundamental crystal operated at twice desired frequency |
| R37 | 100k pot, PC mounting (Mallory MTC-15L1) | | |

ferrite pot cores (Ferroxcube 2616 A1 400 3b9) but the slight bit of improvement is not worth the additional cost. The PC board is designed to accept either the toroidal loading coils or the pot-core assemblies. A 10% variation in the value of the capacitors will not make any noticeable difference to the ear.

This filter determines the passband shape and stopband performance of the receiver to a large degree. For those hardy souls who "roll their own" and wish to tailor a filter to suit some particular need, the three articles by Wetherhold will help lead the way.^{10,11,12}

The input impedance to the filter is nominally 1000 ohms and the load is

nearly 1 megohm. Active filters have been tried but, in this degree of complexity, are far too expensive, consume power, and are temperamental. Active filters generally require both positive and negative power supplies but the National LM 3900 quad-op amp IC may provide some relief for this problem.

Bandpass filters may be used for reception of CW and RTTY and some modification of the agc constants might be desirable too. It is also possible to derive afc voltage from the RTTY term-

*The set of three transformers is available from the author for \$10.00, postpaid.

inal unit and feed it back to a voltage-variable capacitor across the crystal. Why not integrate the receiver right into the terminal unit? This is very handy for autostart operation.

audio-derived agc

Audio-derived agc is about the only means of agc available in a direct-conversion receiver. As mentioned earlier, the agc voltage is reversed because the agc control elements are two mosfets. One in the rf amplifier and another following the lowpass filter in the audio section. A 741-type operational amplifier provides the amplification for the agc independently of most of the speaker audio amplification. The response of this amplifier is modified with a feedback capacitor to slightly delay the attack time and prevent agc hangup on noise spikes.

The coupling capacitor to the agc amplifier is small to prevent response to very low frequencies. The information to be copied by an ssb receiver is a human voice and the object is to tailor the agc response to the voice and minimize response to undesired signals. A very broad peak at about 700 Hz is desirable. The amplifier pulls down the agc voltage quite rapidly and a resistor in series with the S-meter recharges a capacitor providing hand operation.

audio output amplifier

The audio output stage is one of the newer consumer products on the market, the National LM380 IC, 2-watt audio amplifier. This IC outperformed several other ICs and modules that were tried. It is very stable electrically, convenient mechanically, almost indestructible and, most important, inexpensive.

crystal oscillator and digital phase-shifter

Direct-conversion receivers of years past suffered from a lack of operational bandwidth. Some form of LC phase shifter covering a hundred kilohertz or so was considered broadband several years ago.⁵ Digital phase shifters or quadrature gener-

ators are not new but this one requires only a frequency division by two rather than the more conventional division by four.¹³

A single inexpensive IC, a Motorola MC1035P, provides a crystal oscillator, a Schmitt trigger and a differential output amplifier.* The differential square-wave outputs from this stage are at the crystal frequency and, of course, 180 degrees out of phase. These square waves are divided by two in a switch-tail ring-counter which also provides synchronization to the phase quadrature, regardless of turn on or turn off of the receiver. One prototype receiver I built had no synchronizing circuitry and had a nasty habit of randomly choosing its own sideband.

This digital phase-shifter requires extremely fast, well matched ICs. The receivers built before the availability of the MC10131L just did not perform at 10 MHz with more than 20 dB of unwanted sideband suppression. Perhaps a faster IC will appear on the market which will permit operation to even high frequencies but the MC1496 ICs are also a limitation. Since it is nearly impossible to test the rf phase-shifter with conventional test equipment the performance of the overall receiver is the only practical test. The MC10131L IC is not cheap, and it draws a lot of current, but it is the key that unlocks the door to broadband operation.

The crystals are standard fundamental types for 32-pF operation. The PC board has both a trimmer and a shunt capacitor to permit a wide choice of shunt capacitance across the crystal. The crystal frequency is always twice the desired suppressed-carrier frequency. If a crystal is being ordered to copy CW or RTTY don't forget to choose your favorite sideband for copying plus a 1-kHz offset or so. Surplus CR-18/U crystals work fine as do

*Crystals are available from Buck-Man Electronics, 120 South Blake, Olathe, Kansas 66061. Specify crystals for the Phase II Receiver. 1 or 2 crystals, \$7.00 each; 3 - 5 crystals, \$6.00 each; 6 - 15 crystals, \$5.00 each; 16 - 25 crystals, \$4.00 each, postpaid.

many of the overtone crystals oscillating on their fundamental frequencies.

power supply

The receiver circuitry may be powered with ac or dc but if raw ac is used the

construction

With some careful shopping it is possible to build the whole *Phase II Receiver* for about \$60. A club or group purchasing at quantity prices can reduce the cost further and put life back into the club

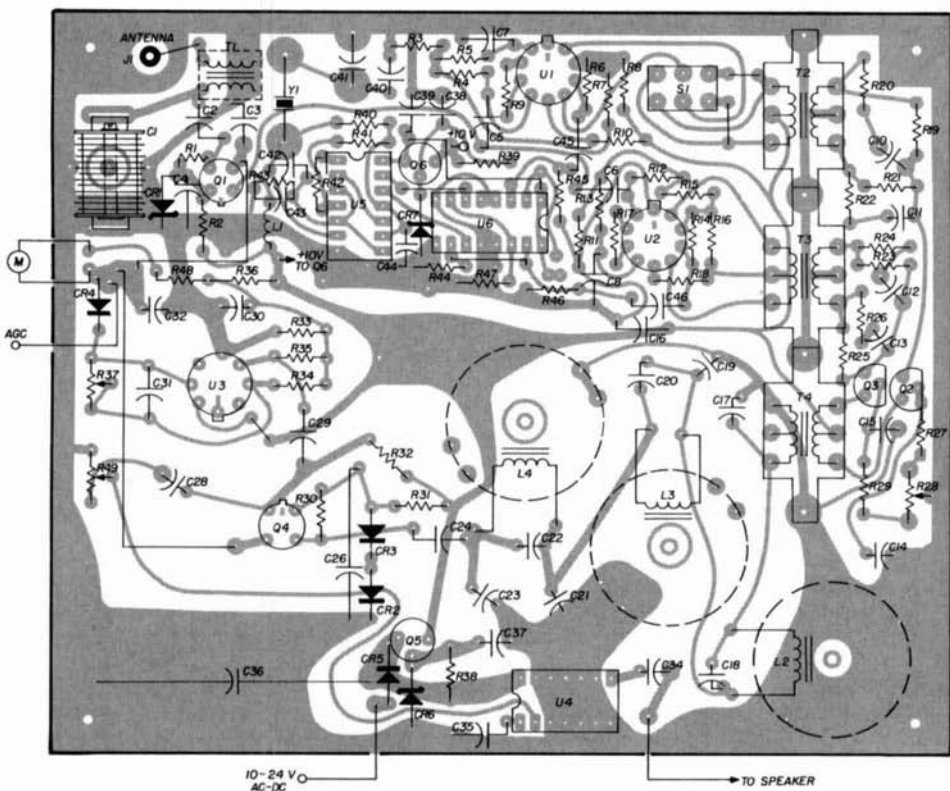


fig. 4. Printed-circuit layout of the complete phasing-type communications receiver.

audio level must be kept low or it will be extremely rough sounding. It is best to full-wave rectify the ac or provide a filter capacitor much larger than the 2000- μ F used on the board. The 10-volt regulator also acts as an active filter to clean up the dc fed to all the low-level circuits. The second regulator provides 6.0 volts for the digital circuitry. Both regulator transistors should have clip-on type heat sinks since they may have to dissipate a couple of watts under extreme conditions.

net, too. Most components are standard stock items and values have been selected to permit quantity purchases. The miniature transformers are not standard but are available below the cost of comparable standard American-made transformers.

The transformers have a red dot on the side with the most turns. The red dot on T2 and T3 is toward the product detectors and the dot on T4 faces R28, the sideband balance pot.

S-meter

Sensitive meter movements are expensive and now even the surplus stock of 100- μ A meters is about gone. A single inexpensive transistor and one resistor will permit use of a readily available 1-mA meter. Most of these meters are not calibrated in S-units or even in dB. The meter in my receiver is very appropriately calibrated in, "wind speed — miles per hour." On 3920 kHz the incoming signals generally run about 80 mph at mid-evening. The transistor and resistor may

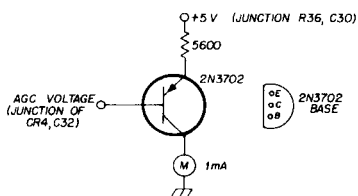


fig. 5. If sensitive 100- μ A meter is not available for the S-meter, this transistor amplifier and 1-mA meter may be used.

be mounted on the board near the agc components or hung on the back of the meter (see fig. 5). Be sure to jumper the old meter pads together to maintain agc action.

Some of the cheap and surplus 741 IC op amps do not have as much output swing as they should and will not pull the agc voltage below 2.0 volts. Even with a good amplifier the voltage will not drop below 1.8 volts. This limits the dynamic range and large signal-handling ability of the receiver. The new Norton or current-mode op amps may be a solution to this problem as well as to the problems of splitting the power supply voltage and floating the amplifier. The LM3900 quad operational amplifier was not available during the development of this receiver but it might be incorporated into a future design with the other three amplifiers used for noise blanking.

alignment

The only adjustments to be made to the completed receiver are to balance the

audio combiner pot for best sideband suppression and to adjust the front-end filter to peak the signal. Of course, the crystal frequency can be trimmed on the nose with the small trimmer capacitor in series with the crystal. Since the product detectors are driven with square waves it might be suspected that there would be strong spurious responses at the odd harmonics.

Data for the MC1496 double-balanced mixer indicates that the second and third harmonic sensitivity should be at least -30 dB even with extremely strong over-driving.¹⁵ The carrier input to the product-detectors causes switching action anyway.¹⁶

troubleshooting

Troubleshooting the receiver is not difficult. The audio output stages can be used to self check the rest of the circuit back to the product detectors. Just remember that the agc voltage is reversed, about 5 volts for a weak signal and nearly 1 volt for strong signals.

A general-coverage receiver will provide a quick check on the crystal oscillator and the digital phase-shifter. You should receive a signal at the crystal frequency and at the desired receiving frequency at one-half the crystal frequency. Integrated circuits U5 and U6 are emitter-coupled logic and are intentionally operated above their normal 5.2-volt supply. The Phase II receiver's low-voltage supply is nominally 6.0 volts which is still safe for the ICs. The oscillator operates more reliably over a wider range and the phase-shifter is slightly more accurate at the higher supply voltage.

operation

Operation of the *Phase II Receiver* at voltages above 20 volts dc is not recommended because of the voltage limitation of the LM380 audio power amplifier IC and the wattage rating of R38. Transistor Q5 gets a little hot under the collar, too. If continued operation at voltages above 20 volts is desired, a 10- or 12-volt, 10-watt zener diode may be added in

series with the power supply line. If only portable battery operation is desired, all the components in the first voltage regulator may be removed since they will only consume power and regulate nothing. However, the input diode, CR5, should be left as a polarity reversal protector.

Unwanted sideband suppression is improved by adding a capacitor from one side of the primary of transformer T2 to the center-tap. This capacitor value varies from 2000 to 10,000 pF with different receivers, but in all cases makes some

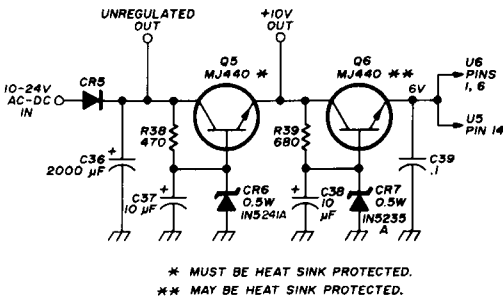


fig. 6. Power supply for the phasing-type receiver operates from 10 to 24 volts, ac or dc.

improvement. Circuit pads have been included on the PC board for this purpose.

Direct-conversion receivers have a peculiar ability that occasionally causes problems. The receiver can receive its own local oscillator. Logically, it would seem that this signal leakage out of the digital phase-shifter would always be within 90 degrees of the received frequency and would be a dc voltage coming from the product detectors. Transformer coupling was used in an attempt to minimize low frequency audio noise caused by self-reception. Certain conditions aggravate the self-reception problem, resulting in an obnoxious buzz. To minimize this problem the following procedures may be helpful. They are listed in order of decreasing importance.

1. Disconnect the frequency counter from the receiver when not taking actual frequency measurements.

2. Ground the receiver to a good ground.
3. Locate the antenna as remotely as possible and use coax feed.
4. Place the receiver board in a well shielded enclosure.

Using a converter with the Phase II receiver seems to present no problems as long as coax is used for signal input.

Strong signal handling, cross-modulation, and overload may be improved by increasing the voltage of zener diode CR1. Although this will result in some loss of sensitivity, on most frequencies below 10 MHz extreme sensitivity isn't all that useful.

No muting feature was provided since it was assumed that the audio output would simply be turned off if a transmitter was in operation. Experimenting with the companion breadboarded phasing transmitter has turned up two more possibilities. Since it is possible to receive your own signal while transmitting it may be desirable to pull the agc line down near ground potential and use the receiver audio as a sidetone signal. The audio can be muted by grounding pin 1 of the power amplifier, U4. A combination of both of these muting methods may be used but the agc line should be left slightly above ground to speed recovery time when switched back to the receive mode.

frequency measurement

Off-the-air frequency measurements are quite easy because there are two unused outputs from the digital rf phase-shifter, either of which may be fed directly to a frequency counter. The exact suppressed-carrier frequency of a sb signal is quickly read.

Reading the frequency of a CW signal or a continuous carrier is much more difficult, believe it or not. Zero beating will not work because there is no output at frequencies near zero beat. The best method I have found for measuring the frequency of CW signals is to compare the 1-kHz output of the counter with a 1-kHz beat note from the receiver on a scope.

This provides exactly 1-kHz offset and can be added to or subtracted from the counter reading, depending upon the sideband used. It is possible to preset some counters to allow for the 1-kHz offset.¹⁴ Crystal drift experienced at 7.6-MHz was only plus or minus 5 Hz over a period of several months.

summary

Four prototypes have been in service for over a year. No two of the prototypes are exactly the same but they all have performed quite well with the exception, perhaps, of the one that chooses its own sideband, but that problem has been cured. Frontend filters have been an absolute necessity to permit operation of adjacent transmitting equipment. Performance is good enough that the Collins 75A-4 has been on the shelf for six months and the R390-A is a standby.

The most obvious follow up project for the receiver is a companion transmitter and a vfo. A breadboard transmitter has been in operation for several months with excellent results, considering the output power of one watt. Signal quality has been the key to success with such low power.

The transmitter is a sort of *reciter* because it does transceive with the receiver and it uses the receiver rf digital phase-shifter. It provides a couple of unique features: it is possible to transmit on one sideband and receive on the opposite — even simultaneously, within the limits of the unwanted sideband suppression. It is also possible to transceive but to monitor your own signal off the air would require a separate receiver and transmitter.

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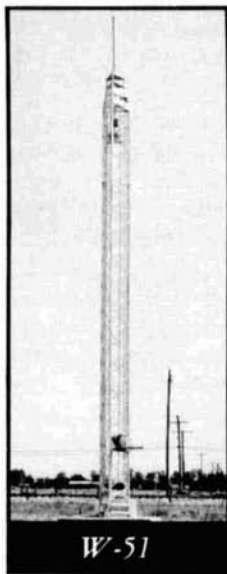
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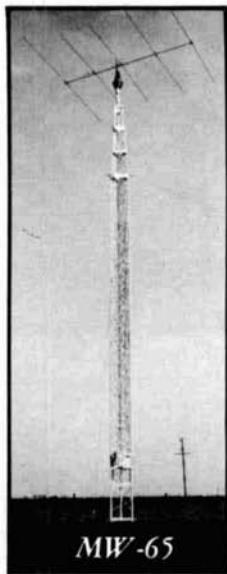


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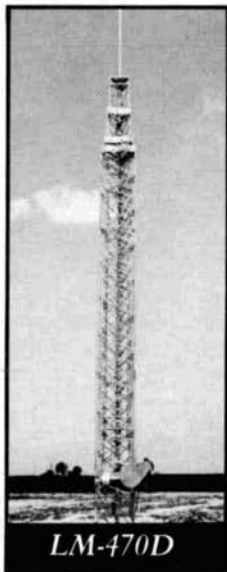
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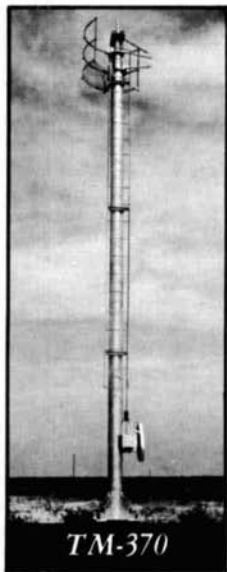
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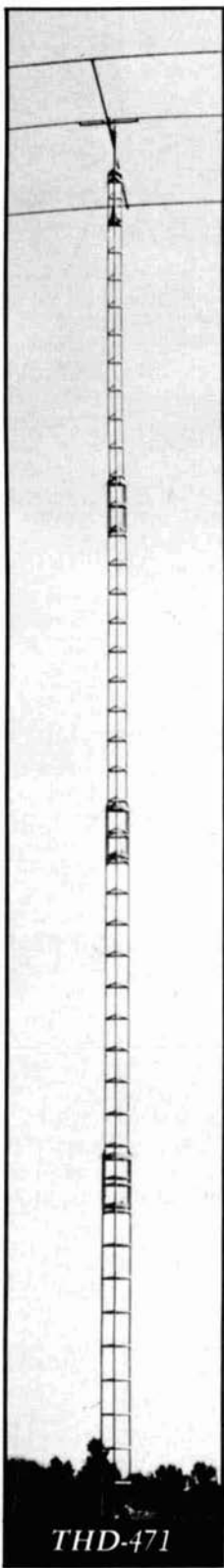
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high-gain log-periodic antenna

for
10, 15 and 20

This 17-element
log-periodic antenna
provides approximately
13-dB gain
over three
amateur bands

In a previous article I described two fixed, doublet-type log-periodic antennas which cover the entire frequency range from 14 to 30 MHz.¹ Although both of these antennas have 12 elements, one, 70-foot long, provides approximately 10-dB gain. The other, 40-foot long, gives approximately 8-dB forward gain.

Since writing that article I have built eight more log-periodic antennas for various frequency ranges, including several for 40 meters.² One of these log periodics which is especially interesting uses 17 elements to provide 12- to 13-dB forward gain on the amateur 20-, 15- and 10-me-

ter bands. This antenna is of interest to amateurs who want a single fixed wire beam aimed in one particular direction and it will be described here.

the antenna

The high-gain, three-band log periodic shown in fig. 1 is 100-foot long and has an apex angle of 16 degrees ($\alpha = 8^\circ$). The minimum space required for this antenna is approximately 125-foot long by 80-foot wide. Four masts or other supports are required. The antenna is suspended between the four masts with two nylon catenary side lines as shown in fig. 2.

Unlike the antenna described in reference 1, the center open-wire feedline carries some of the weight of the antenna. This eliminates two of the nylon support lines used in the earlier design.

I used number-15 aluminum wire for both the center feedline and for the 17 active elements. The use of aluminum wire minimizes overall weight of the large antenna. This wire is manufactured for use in electric fences and is available from Sears (catalog number 13K22065) at \$8.70 for a quarter-mile roll. Approximately 570-feet of wire are used in this three-band log-periodic antenna.

Although this aluminum electric-fence wire is strong and inexpensive, be careful not to put any kinks in it when you are putting the antenna together — aluminum wire breaks easily after it has been once kinked. As with any aluminum wire, special precautions must be taken when making electrical joints and splices.

If you use sturdy steel masts or wooden poles for the four antenna supports, copper wire can be used for the antenna.

George Smith, W4AEO, 1816 Brevard Place, Camden, South Carolina 29020

However, the weight of the antenna will be much greater. At my station I use 75-foot-high pine and cedar trees for supports, so antenna weight must be kept to an absolute minimum.

construction

As with my previous log periodics, the center insulators are made from ¼-inch thick lucite or plexiglass as shown in fig. 3. The center element ends are attached to the two outer holes; the center open-

Ceramic egg insulators can also be used for the end insulators for the front and rear elements, up to 250 watts. For higher power, 6- to 8-inch Isolantite antenna insulators are better. Monofilament fishing line, 40- to 50-pound test, is used as end insulators for the rest of the elements. I used 40-pound test monofilament from Sears (catalog number 6KV32232), priced at \$1.88 for a 325-yard spool.

The center feedline to each of the

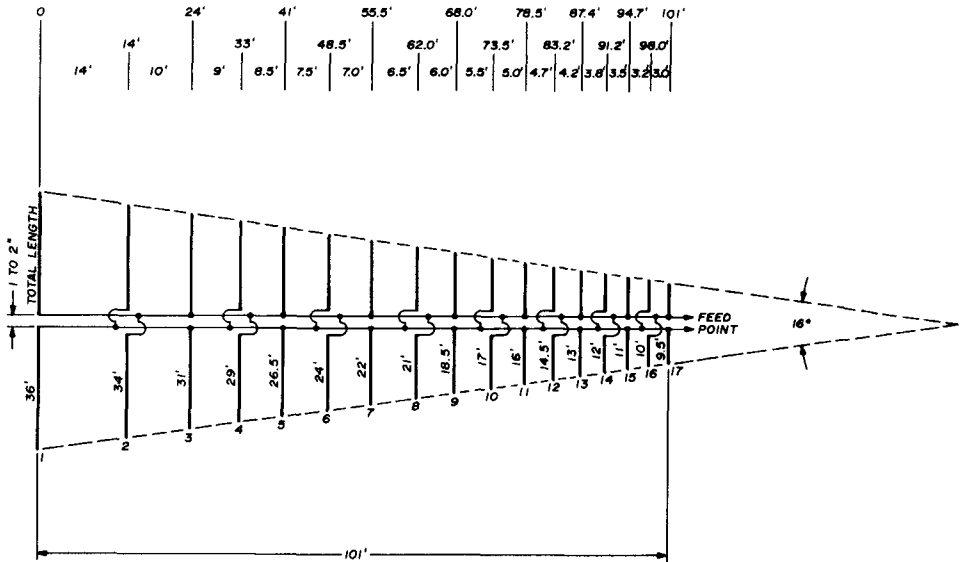


fig. 1. High-performance log-periodic antenna for 20, 15 and 10 meters uses 17 elements to provide approximately 13 dB gain. Installation requires four support masts and a space 125-feet long by 80-feet wide.

wire feedline passes through the other two.

The center insulators are secured to the open-wire feedline by serving several turns of number-18 tinned copper wire over the feeders on each side of the insulator as shown in fig. 4.

The photograph shows a mockup of the center feedline and element arrangement. (In this mockup the elements are much more closely spaced than in the actual antenna.) Ceramic egg insulators are required at the front (element 17) and rear (element 1) because the homemade insulators will not take the stress at these points.

elements must be transposed as shown in fig. 1. The photograph shows that the necessary crossover is located below the center insulator — this provides a rain drip and lowers the center of gravity of the antenna. Since this log periodic uses an odd number of elements, the front and rear element connections do not have to be transposed, and the center feedline can be connected directly to the ends of the front and rear elements. You can use a 4:1 balun and coaxial line or 300-ohm tv twinlead with this antenna, as described in the previous articles.

The photo also illustrates the aluminum-to-aluminum connections between

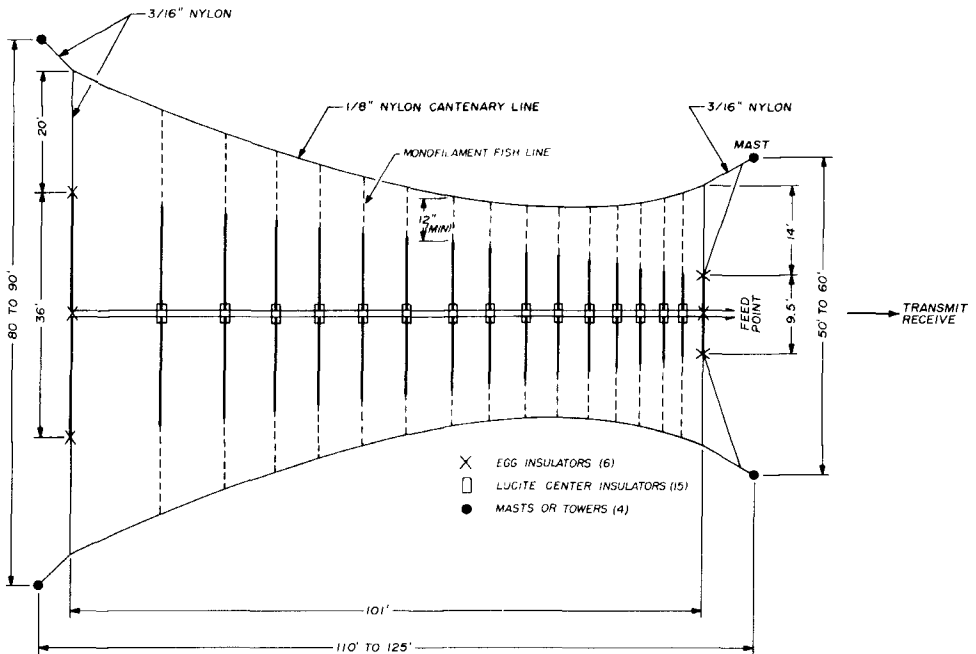


fig. 2. Installation of the 17-element log-periodic antenna. Masts should be a minimum of 40-feet high — 70 feet is better.

the elements and the center feedline. The center element ends are cut 10 to 12 inches longer than the specified element length. This extra length is then fed through the end hole of the center insulator and given three wraps over the element to secure it to the insulator. The remaining length is connected to the center feedline.

All aluminum-to-aluminum electrical connections use mechanical joints. When connecting the transmission line or balun to the antenna, use stainless steel or cadmium-plated hardware. By using large cadmium-plated shakeproof washers with internal teeth good contact can be made to the aluminum wire. I used this method with my first log periodic, and it has been in constant service since September, 1970, with no corrosion or electrolytic problem, to date.

If copper conductors must be used at the feedpoint, use large cadmium-plated terminals or solder lugs, bolting them to the aluminum wire with plated screws and nuts. This eliminates any direct alu-

minum-to-copper contact that could lead to problems with electrolysis.

performance

This is the highest gain log periodic I have built so far. It is beamed west and is installed about 60 feet above the ground. Stations in California often tell me I am the strongest W4 on the band. Considering that I'm using a barefoot transceiver, while most of the competition are running 1000 watts, it gives me satisfaction to know that by properly using a few hundred feet of wire, such gain is possible for less than \$20.00.

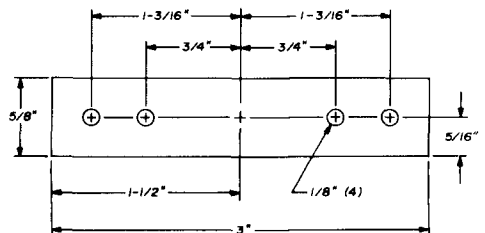
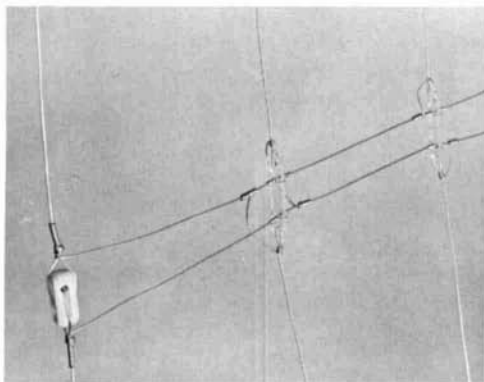


fig. 3. Center insulators for the log-periodic antenna. Material is 1/4" lucite or plexiglass.



Mockup of center feedline showing installation of the center insulators and mechanical aluminum-to-aluminum connections.

I have not tried to make quantitative front-to-back or side attenuation tests, but from on-the-air tests signals from stations off the side of the antenna seem to be about 30-dB down. This is a great help here for attenuating the extremely strong signals that pour in from South and Central America.

I have not been able to obtain much data on the front-to-back ratio as there is not much to the east of here except the Atlantic Ocean. However, I was recently monitoring a VK1 in the evening by long path from the east. He was about S4 on my non-gain, non-directional antennas but was absolutely nil off the rear of the 17-element log periodic. I was also recently monitoring a CR6 in Angola — he was good S5 copy with my non-gain antenna, but was only S1 or less off the back of the log periodic. These simple observations seem to indicate that this log

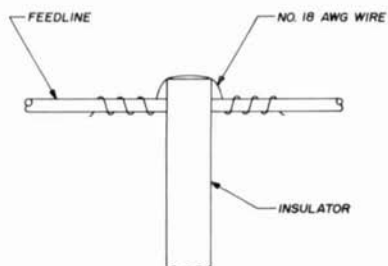


fig. 4. Lucite insulators are secured to the center feedline with a few twists of no. 18 wire.

periodic has a better front-to-back ratio than the other log periodics I have built in the past.

When I designed this long log periodic I tried to improve the front-to-back ratio by increasing the spacing between elements 1 and 2 to 0.2-wavelength. This is 14 feet, as opposed to a spacing of 11 feet which would be normal. Normally the front-to-back ratio of a log periodic is 14 to 15 dB minimum. However, to date I have not been able to determine if the increased spacing between elements 1 and 2 was of any help. The rest of the element spacings are normal for a log periodic having this boom length and apex angle.

summary

If you need a high-gain, fixed beam

table 1. Price list of materials for the 17-element log-periodic antenna.

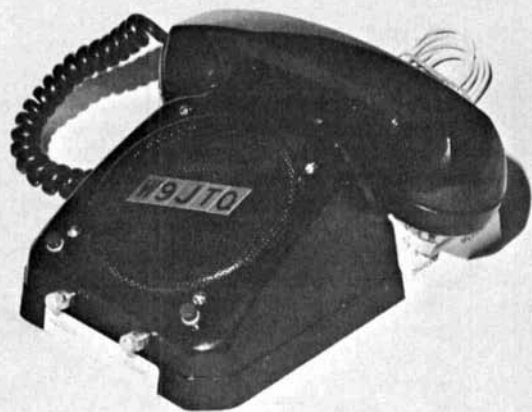
600-feet	no. 15 aluminum electric-fence wire	\$ 3.60
250-feet	1/8" nylon line	7.50
100-feet	3/16" nylon line	5.00
25 sq. in.	1/4" lucite for center insulators	1.00
6 each	ceramic egg insulators	.90
1 roll	40-pound monofilament fishing line	1.88
		<u>\$19.88</u>

and have the available space, a long log periodic should be considered. Even a long log periodic of this type requires less acreage than a rhombic antenna designed for the same gain on 20 meters. Furthermore, unlike the rhombic, the gain of a log periodic does not fall off at the lower end of the frequency range. If anything, the log periodic seems to perform slightly better at its low frequency end.

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ham radio



two-meter fm base station

A compact rig
with 12 channels
built into
a telephone
desk set

Al Ericson, W9JTO, South Washtenaw Avenue, Chicago, Illinois

For the amateur who wants his 2-meter fm base station in the living room, this desk set should be the answer. At a glance it appears to be just another telephone. But underneath are 12 channels for transmitting and receiving, each individually selectable. The desk set uses Motorola HT-220 handy-talky circuit boards, which are easily adaptable to a compact rig such as this. In addition to the rf circuits, an ac regulated power supply completes the desk set base station.

If you're close to a repeater or have an efficient antenna, the two watts output from the desk set will be sufficient to capture the repeater with full quieting. More power can be obtained by adding an outboard solid-state amplifier, such as the Dycomm 101-500E, which can be remotely located and fed with coax cable. The speaker in the desk set, with the 1/2-watt audio output from the receiver section, is ample for base-station use.

The photos and schematic, together with the instructions furnished, should provide sufficient guidance for those who would like to duplicate the desk set.

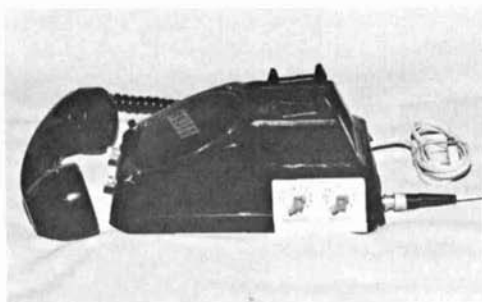
construction

Space is limited inside the telephone desk set, but with care all components can be accommodated. A parts list is provided in **table 1**.

The following additional holes must be drilled in the desk set metal base (see photos for dimensions):

1. Three holes for mounting the HT-220 chassis assembly.
2. Three holes for the dc power-supply circuit board.
3. Two holes for the power-supply transistor heat sink.
4. Four holes for the power-transformer mounting bracket.

4. Four holes for mounting the ac line switch and fuse holder.



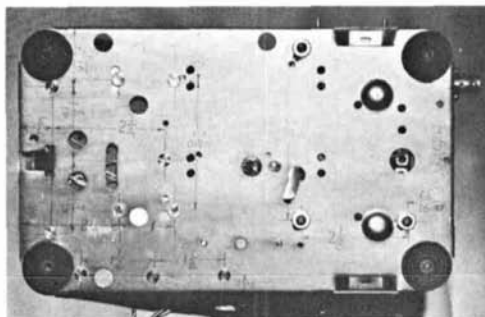
Separate channel selector switches for transmit and receive.

The following parts and subassemblies are mounted on the telephone desk set:

1. HT-220 chassis assembly (refer to photos and description).
2. 110 volt/24 volt ac power transformer with two right-angle metal mounting brackets.
3. Dc power supply circuit board with three 3/8-inch-high mounting posts.
4. Dc power supply regulator transistor, mounted on sheet-metal heat sink.
5. Coax connector, mounted to rear edge of base.
6. Ac line switch, fuse, and line cord.
7. Volume and squelch controls and indicator lights.
8. 40-45 ohm dynamic speaker.

description of subassemblies

The HT-220 circuit board is mounted in a Motorola part No. 7D83124H-1-D metal base, which acts as the heat sink for the final amplifier transistor. This assembly is mounted on 5/16-inch posts at the four corners of the telephone desk-set



Baseplate hole layout.

5. Two holes and a small cutout in the rear lip of the base for the coax rf output fitting (not visible in the photo of the base).

Drill and file the following holes in the plastic case:

1. Two holes for volume and squelch controls (front edge).
2. Two holes for channel selector switches (right side).
3. One slotted hole on rear edge for the coax connector.

table 1. Complete parts list for the compact two-meter base station.

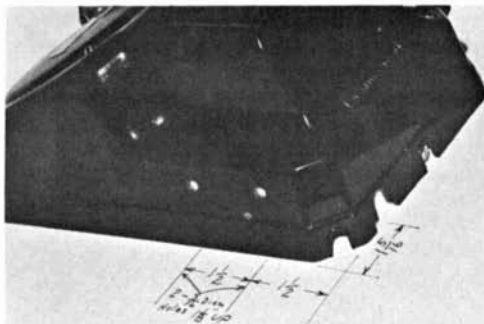
quantity	item	quantity	item
1	Motorola desk set housing with cradle switch, speaker grill, and handset	1	miniature mike cartridge for Motorola HT-220 with rubber mounting pad (part no. 50-82157JO1)
1	Motorola HT-220 circuit board with control relay for remote operation	2	24-volt Dialite pilot lights
1	Motorola 7D83124HO1-D metal chassis housing with mounting screws for HT-220 circuit board	1	110-volt/24V 1 amp transformer (Olson part no. T-290)
4	3/16 in. diameter x 5/16 in. long spacers to mount housing to telephone base	4	1-amp 200-volt rectifier diodes (Radio Shack part no. 276-1102)
1	Motorola 15E84004/HO1 plastic spacer sleeve with mounting screws for crystal deck circuit board	2	500 μ F, 35-volt electrolytic capacitors (Radio Shack part no. 272-1018)
1	chassis-mount BNC coax connector for antenna output	1	Motorola HEP-247 transistor for regulator
1	25k volume control - use miniature control from HT-220 circuit board - part no. 18-83561HO2	1	Motorola HEP-607 15-volt 1/2-watt zener
2	5k squelch control (Motorola part no. 18C83560HO1)	1	1500-ohm 1/2-watt resistor
2	miniature knobs for above for 1/8 in. diameter shaft	1	3/4-amp AGC fuse (Radio Shack part no. 270-1272)
2	12-position miniature Grayhill switches for channel selectors (part no. 51YY23047-1-12N)	1	3-3/4 in. x 2-5/8 in. perf board (punched) for power supply (Olson part no. K-116)
2	bar knobs for above (for 1/8-in. shaft)	1	spst toggle switch (Olson part no. SW-384)
1	4-inch dynamic speaker with 40-50 ohm voice coil	1	panel-mounted fuse holder (Radio Shack part no. 270-364)
		1	6-terminal barrier strip (Radio Shack part no. 274-650)
		1	special Motorola fuse (do not substitute) (Motorola part no. 65B82896B03)

Note: The Motorola HT-220 circuit boards, desk set, and Motorola parts are available from Spectronics, Inc., 1009 Garfield Street, Oak Park, Illinois 60304. When you order your HT-220 circuit board, request the schematics. Cost is 10 cents per 8-1/2 x 11 page, or about \$1.00 a set.

base. The two Grayhill part no. 51YY23047-1-12N 12-position channel switches are mounted on the 1/8-inch-thick battery end of Motorola part no. 15E84004HO1 plastic extension (see table 1) for the thick-pack HT-220, from which the battery section is sawed off and discarded. The hollow tubular member that houses the collapsible antenna must also be sawed out of the inner part of the plastic extension sleeve to provide space for the transmit and receive crystals, their coils, and the channel switches. Note that this sleeve is turned 180 degrees from the way it is normally mounted in a handy-talky.

A special circuit board was prepared for the 20 channels on the board which,

including the four channels on the HT-220 board, gives 12 transmit and 12 receive channels. This board has holes above each tuning slug in the HT-220



Hole dimensions for channel selector switches and antenna coax connector.

chassis, so that the rig can be tuned without disassembling the crystal deck from the HT-220 deck. One crystal coil slug is inaccessible from the top, but a hole already exists in the bottom of the desk-set base through which it can be adjusted.

A terminal strip is fastened to the side of the HT-220 chassis and is used to connect the telephone handset terminals to the circuits. Squelch and volume controls are located on the front skirt of the handset, so leads must be extended from the HT-220 chassis assembly to these controls, the dc power supply, and the handset cradle switch. See photos for details and refer to the schematic (fig. 1).

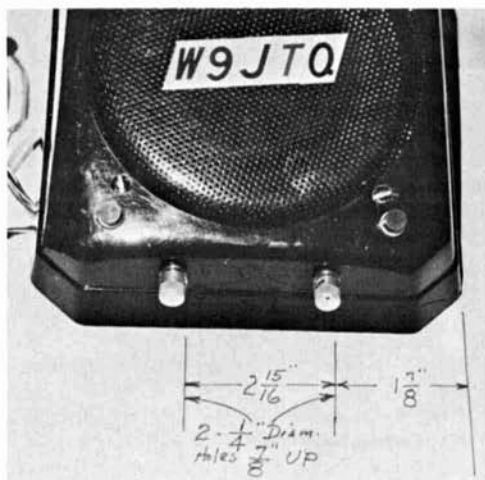
HT-220 board preparation

The HT-220 circuit board, as received, contains a relay for remote control of a speaker and microphone. Unsolder and remove the following:

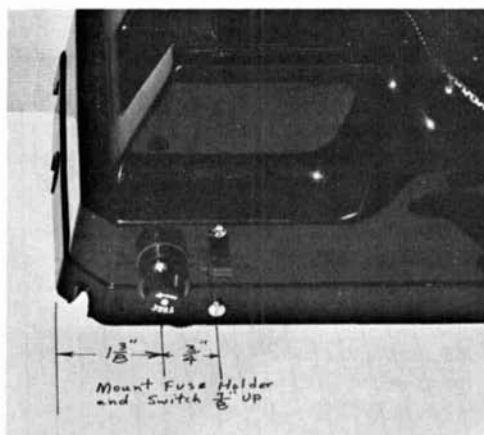
1. Green lead from pin 10 on IC 101 on the back side of the board.
2. Blue/green lead.
3. White/brown lead.
4. Brown/green lead.
5. 80-ohm resistor and green/white lead.
6. Ground lead (black) at edge of board by relay.

Do not remove the following:

1. Grey, yellow, violet leads (squelch control).
2. White/orange, white/yellow, white/blue leads (receive crystal switch).
3. White/red, white/green, white/brown leads (transmit crystal switch).
4. Black, brown, green leads (volume control).
5. Black/red (relay-control lead).



Mounting dimensions for volume and squelch controls.



Mounting dimensions for ac power line fuse and switch.

lead dress. All the above leads will either be extended or replaced. Use Teflon-covered wire for extensions if possible. Unless you're experienced in working on printed-circuit boards, it is recommended that you extend the wires rather than try to run new leads from the board. Make a chart showing the relationship between original wire colors (on the board) and those you use to make the extension. Use a 3/8-inch-long piece of 3/64-inch-diameter heat-shrinkable tubing over each splice. Now continue as follows:

1. Clip black, green and brown leads 1/2 inch from volume control and extend each lead 9 inches. These leads will be

later connected to a volume control on the speaker.

2. Unsolder the red leads from the on-off switch on the volume control. Unsolder and remove the red lead connected to the pin jack on the board. (This pin jack *will not* be used for the + battery connection.) Join and extend the two red leads removed from the switch to about 3

3. Install the crystals as follows: Y-1 (transmit) and Y-101 (receive) nearest the end of the board; Y-201 (transmit) and Y-301 (receive) next to Y-1 and Y-101.

4. Extend the brown, yellow and purple leads 7 inches. These leads will be connected later to the squelch control.

5. Extend the following leads 4 inches: black/red control lead from the relay and the black (ground) lead from board next to the relay.

Note that the transmit section runs vertically along one side of the board and is easily identified by the final amplifier power transistor. The receive section runs along the opposite side of the board.

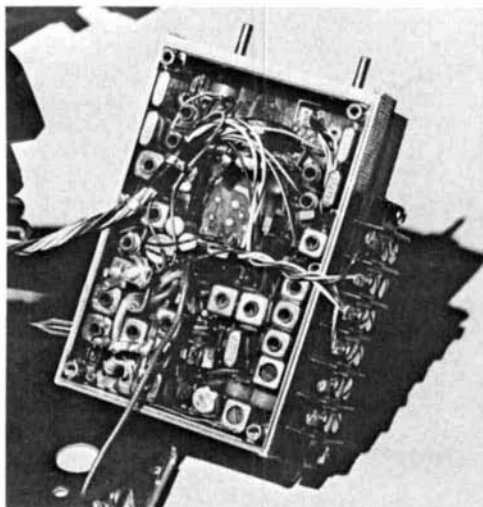
crystal-deck circuit board

The crystal deck was designed with the following objectives in mind:

1. To be able to peak up the HT-220 circuits with the crystal deck in place.
2. Isolation of crystals and peaking coils from the transmitter rf power output transistor.

These were met by using the layout shown in the photo showing the finished crystal deck wired to the selector switches. Receive crystals are located in the two left-hand vertical crystal holders and in the two left-hand positions of the upper horizontal molded rubber crystal holders. The transmit crystals are located on the right-hand side of the board. Note that the lower right-hand corner of the board is not used (it is directly over the transmitter power output transistor).

assembly. The circuit board is a 2-1/4x3-1/2-inch piece of fiberglass reinforced epoxy circuit board stock. A parts list is presented in **table 2**. The trimmer coils for each crystal are press-fitted into the holes in the circuit board. Note that holes have been drilled into the crystal deck board directly above the coils on the HT-220 circuit board so that the entire coil set can be peaked without disassembling the crystal deck. Press-fit term-



HT-220 chassis assembly (top view).

inches. (One red lead goes to the relay; the other goes through an rf choke to the circuit board.)

channel selector. The channel-selector switches are separate 12-position Grayhill switches which are used for selecting the transmit and receive channels. The two transmit and two receive channels on the 220 circuit board are connected to positions one and two as shown in the schematic diagram in **fig. 1**. It is not necessary to strap the selector switches as is required when one switch controls both transmit and receive channels. This is because you can select any channel to transmit and/or receive, independent of one another. When you have completed wiring the selector switches make a chart showing the crystal frequency of each transmit and receive channel position.

inal lugs are located along the edges of molded rubber crystal holder. Short lengths of no. 18 solid copper wire are used as terminal lugs for the connections between the end of the trimmer coil and the lead wires to the band switches. Using pliers, pinch the soft copper wire on each

It is recommended that the wiring on the circuit board be completed before connecting the leads to the two selector switches.

The layout shown worked out well and met the objectives. If you eliminate the need to tune up the HT-220 circuit

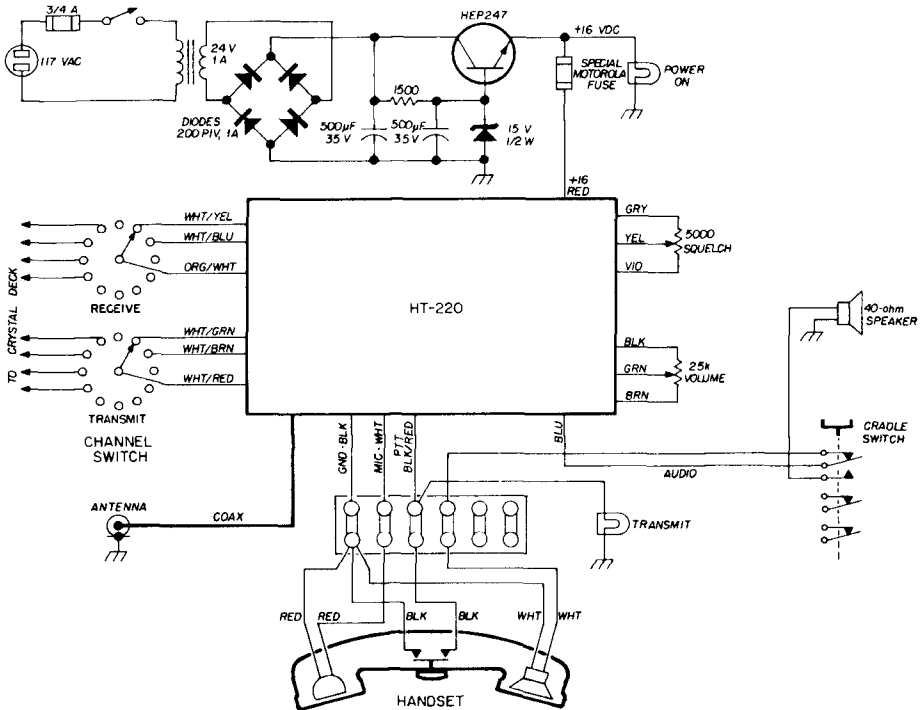


fig. 1. Power supply and interconnecting circuits for the HT-220 desk set base station.

side of the circuit board to lock it in place. Number 16 solid-copper wire is also used as the ground strap between the molded rubber crystal holders.

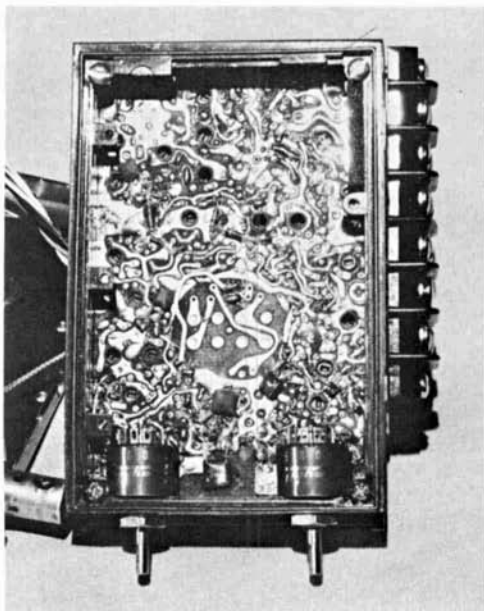
The 1/8-watt resistors in parallel with each crystal are mounted over the top of the molded rubber crystal holders between crystals. They will just fit. Don't try to use a resistor larger than 1/8 watt. The terminal at the very top of the circuit board between the two selector switches is connected to the discriminator circuit to accommodate a high-impedance meter, which can be used to zero in each receive crystal on the channel.

board without removing the crystal deck, considerably more leeway can be used in the layout.

One word of caution: with transmit and receive channels on separate switches, you must double check each time you change channels to be sure you have both the transmitter and receiver on the proper channels for the repeater you are working.

power supply

Fifteen volts at 500 mA are supplied by the power supply. Note that the transformer recommended (table 1) must



HT-220 circuit board (bottom view).

fit under the handset cradle switch. If you substitute another type of transformer, make sure it will fit into this space. All other components, except the voltage regulator transistor, are mounted on a perf board located under the speaker (see photos for details). A 15-volt zener controls the regulator transistor, which is mounted on a metal heat sink at the left-hand side. The regulated power transistor is insulated from the heat sink with a thin mica sheet. Use a transistor mounting kit and template to prepare the heat sink and to mount and insulate the transistor. Silicone grease should be used between the transistor and metal heat sink.

Note the use of component lead wires through the holes in the perf board for mounting and wiring the components. Mount the ac line switch and fuse holder. Ribs inside the plastic case must be cut off with a sharp wood chisel to accommodate the line switch and fuse holder. Next, connect the line cord. The lug on the end of the fuse holder may have to be partially cut off and insulated with tape to clear the HT-220 chassis.

Leave a service loop so the top plastic cover of the desk set can be removed

while working on the set. Also, note that all leads except the antenna coax are in one cable so that the chassis can be easily removed for servicing.

miscellaneous mods

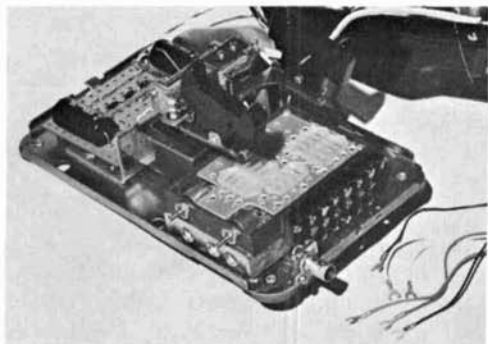
microphone. The handset carbon mike is removed and a Motorola miniature magnetic cartridge unit (table 1), made for the HT-220, is substituted. See photo for mounting details.

speaker. The handset is wired so that the speaker is enabled when the handset is in its cradle, and audio is switched to the earpiece when the handset is lifted from the cradle. The 40-45 ohm, four-inch-diameter speaker must be thin enough so it won't interfere with the cradle-switch level arm. Although the 4-ohm speaker supplied with the handset has a special cutout in the metal support arms, this speaker can't be used in this application because its voice coil impedance is too low for the HT-220 set, and its magnet is physically too large and will interfere with the power supply circuit board.

top cover assembly. To assemble the top cover on the desk set, remove the screw on the HT-220 chassis at the end nearest the right-hand side of the base, and

table 2. Crystal deck parts list.

quantity	item
1	3 x 4-inch fiberglass reinforced epoxy circuit board (Circuit-Stik Quik Circuits part no. 9354 or equivalent)
10	Motorola 24-83638H14 coils - (transmit)
10	Motorola 24-83638H13 coils - (receive)
5	Motorola 7-84274H01 molded rubber crystal holders
10	Motorola 6S185B78 1/8-watt 820-ohm resistors (receive)
10	Motorola 6S185B75 1/8-watt 470-ohm resistors (transmit)
21	press-fit PC board solder terminals
2	flat head Phillips screws
1 ft.	no. 16 bare copper wire for ground straps and coil terminals
20 pcs.	no. 26 gauge Teflon insulated hook up wire, 5-inches long

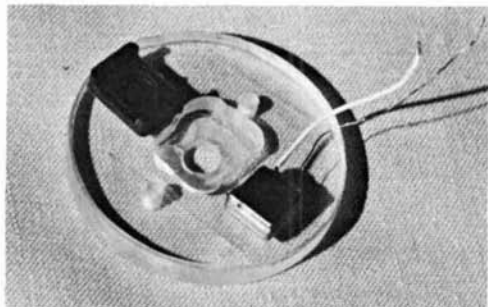


Crystal deck circuit board, BNC coax antenna connector, and terminal strip for handset.

loosen the rear screws so that the HT-220 chassis can be tilted upward to get the channel switch shafts through the holes in the right-hand side of the plastic telephone-set housing. The cradle levers must be manipulated through their slots, and the front hook on the bottom base must engage the slot at the front of the cover. It may be necessary to wedge the hook in place with a screwdriver.

Check the cradle switch to ensure it works freely after the screw at the rear of the desk set housing has been tightened. Note that the on-off switch bottom mounting lug should be on the inside of the lip on the base. Loosen this screw while assembling the set and retighten. Install the channel switch knobs.

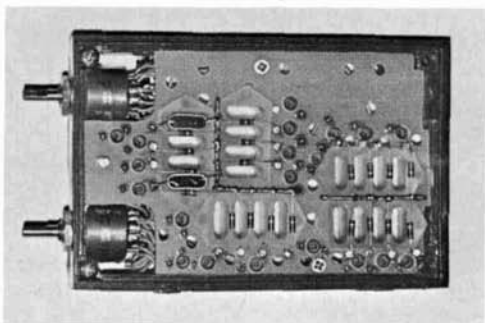
rf section. Small padding capacitors are sometimes needed in the driver and final-amplifier circuits. Add these capacitors, one at a time, as you go through the tune-up procedure and determine if they



HT-220 miniature mike cartridge, molded rubber holder, and plastic adapter plate.

help to increase power output. Monitor the dc input to the HT-220 board during tune up, and do *not* keep the power on for more than a few seconds if the current exceeds 425 mA, since there is danger of damaging the driver transistor. Adjust final-amplifier tuning to reduce current to 400-425 mA.

When feeding a remote power amplifier, limit the length of small coax cable used at the output of the desk set to five feet or less. If you must run a longer cable to the remote power amplifier, use larger cable; preferably RG-8A/U. The short length of small-diameter cable at the desk set is only meant to give flexibility in moving the radio around on the desk.



Assembled crystal circuit board connected to selector switches.

final remarks

Schematics and tune-up instructions should be obtained when you buy your board (available at nominal cost). The matching filter between the coax feed line and antenna is not necessary; the match is satisfactory without it.

Name plates for the channel switches, volume control, and squelch control help dress up the desk set. Your call letters could be substituted for the Motorola name escutcheon on the speaker grill.

This is a very nice rig. While it's a narrowband set (5 kHz), it accepts 8 - 10 kHz deviation without much distortion and sounds fine on most repeater operations.

ham radio

television DX

Chasing broadcast
television DX
is a step above
short-wave listening,
and provides
some interesting data
on vhf
propagation modes

There is a usual pattern leading up to the time when a person becomes a ham. Many of us started out by listening to a distant station on an a-m broadcast radio, only to graduate up to shortwave listening. And finally, often with the aid of an amateur acquaintance, we worked for, and earned, an amateur radio license.

My own interests followed a somewhat different route. I, too, went through the listening stage, but I was rather intrigued with *seeing* DX as well as hearing it. What I am referring to of course is *TV-DX* — receiving normal television stations, during abnormal conditions, over relatively great distances.

Television DX is made possible by the same propagation vehicles as DX on the

vhf and uhf amateur bands. Band openings are just as exciting, and with the added dimension of video, far more dramatic. Somehow, *watching* 1000-mile distant stations float in with sparkling clarity or even heavy snow has an attraction all its own. Suddenly, you're *seeing* heterodynes, meteor bursts and auroral flutter. Whether the signals are originating from a five-megawatt station or a low power relay, the excitement is still there.

As you will see, television DXing can also be of practical advantage to the amateur. Whether it is used as a research tool or simply as an early warning device for vhf and uhf openings, television DX should be more than a novelty to the serious vhf enthusiast. This aspect of TV DX will be covered later in this article.

propagation

Without exception, the same types of propagation that affect the vhf ham bands affect the TV broadcast channels. Since much has already been written in handbooks and magazines about vhf and uhf propagation, and because of space limitations, I have chosen to include only brief details here. Several references to more detailed studies of vhf propagation are included at the end of this article. It is, however, worth pointing out that you should avoid older texts on the subject. Much of what we know about vhf and uhf propagation has only been detailed in the past 15 years or so. Most earlier texts are full of false assumptions. The articles cited will provide the most up-to-date information.

Tropospheric bending Tropo, which is sometimes known as extended ground wave, is a weather related phenomenon affecting both the vhf and uhf television

Morrie S. Goldman, WA9RAQ, 5815 North Christiana Avenue, Chicago, Illinois 60659

channels. Several variations of this propagation mode exist, all requiring the influence of a high-pressure area. Basically, when a temperature inversion takes place in the troposphere, a strata develops which forces vhf (and higher) signals to follow the curvature of the earth. This continues for the length of stratified layer, anywhere from 60 to 1000 miles.

Sometimes two layers form close enough to each other to simulate a wave guide, *ducting* signals for 350 to 1000 or more miles. *Tropospheric ducts* often channel signals over all points between the transmitter and receiver, much like skip. Since the duct is a waveguide, it may affect a relatively small frequency range (such as part of the uhf band), or it may be large enough to affect the entire TV spectrum. Ducts are most common along the edge of a weather front.

The warmer months and especially the autumn are best for tropo, although it can occur during any season. Best times are usually around sunrise and sunset when rapid heating and cooling in the troposphere takes place. Tropo is characterized by steady signals and slow fading.

Sporadic-E skip (Es) Also known as short skip in amateur circles, Es is most common in the late spring and early summer months, with a secondary lesser peak occurring from mid-December to early January. Best times are most often from mid morning to early afternoon and from early evening to about 2230, local time. Sporadic-E occurs when vhf signals hit sporadic patches or *clouds* of ionization in the E layer of the ionosphere and are refracted to a distant point. Typical distances for a single hop range from approximately 450 to 1400 miles.

Double and even triple hops are possible and have been reported, but are not very common. Es begins low in frequency and as the density of the patch increases, so does the muf. Es commonly affects all of the low band (channels 2-6) and occasionally extends to channels 7 and 8 in the high band. Es is the most unpredictable and misunderstood of all the types of ionospheric propagation.

Sporadic-E propagation is characterized by strong signals and deep fading. Reception can last for minutes, hours and in some rare cases, days.

F2 layer skip (F2) During years of peak sunspot activity the F2 layer of the ionosphere can provide a daily reflective barrier to vhf signals. Skip distances begin at about 1700 miles. With multiple hops, the ultimate range is unlimited. During the past sunspot peak, the muf seldom reached our channel 2, but did bring in 41-MHz TV audio signals from France and England. In 1957, George Palmer of Williamstown, Victoria, Australia, set the world's TV-DX record by receiving BBC-TV audio by long path F2 over a distance of 14,500 miles. The video was received on another occasion during the same year by short path F2 over a distance of 10,400 miles!

Auroral Scatter (As) The *aurora borealis* or northern lights does more than wipe out low-frequency DX — it causes DX to occur at vhf. Though once thought to be relatively well understood, auroral scatter is of increasing interest to researchers. It can propagate signals anywhere from several hundred to several thousand miles. Aurorally propagated signals are characterized by rapid flutter. In fact, this flutter is usually so intense that it garbles television and audio signals beyond recognition. Only during a small percentage of the magnetic disturbances are signals stable enough to be useful.

Peak signals for auroral scatter DX appear most often toward magnetic north. Reception and visual auroral sightings are far more common in the northern states and Canada than in southern regions.

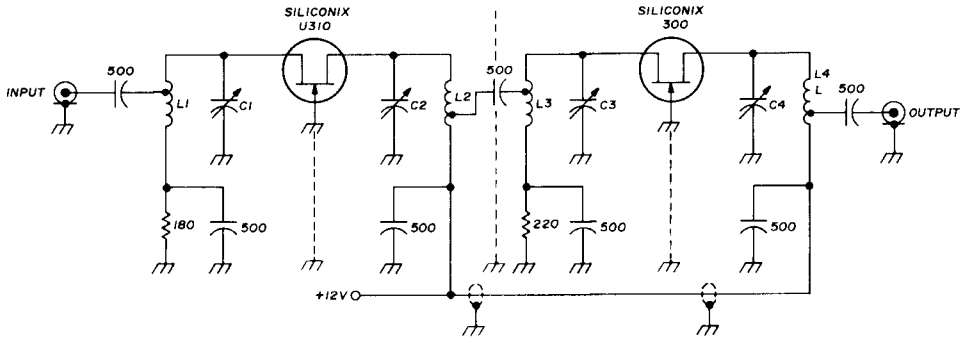
Auroral peaks seem very closely tied to sunspot peaks. According to ionospheric physicist Gordon P. Nelson, "magnetic and solar activity may lead or lag each other in alternating cycles."* The

**Auroral Disturbances*: A talk presented by Gordon P. Nelson at the 1972 convention of the Association of North American Radio Clubs in Boston, Massachusetts on July 15, 1972.

magnetic peak lagged the solar peak in cycle 20, so we would expect the reverse to be true in cycle 21.

Meteor scatter (MS) When a meteor is pulled toward the earth and begins to burn from friction, it leaves an ionized trail behind. This short-lived ionization

meteor scatter is from about 0400 to 0800 local time when many TV stations are displaying test patterns and ID slides. From midnight until noon, local time, we are at "the front of the earth," catching the greatest number of meteors with the greatest force. There are some daylight



low-band

- C1,C2 3-32 pF variable (E.R. Johnson)
- C3,C4 167-130-1)
- L1 5 turns no. 16, 3/4" diameter, tap down from hot end for best performance
- L2 6 turns no. 16, 3/4" diameter, tapped 3/8-turn from cold end
- L3 5 turns no. 16, 3/4" diameter, center tapped
- L4 6 turns no. 16, 3/4" diameter, tapped 1/8-turn from cold end

high-band

- C1,C2 1.5-5 pF (E.F. Johnson 167-102-1)
- C3,C4
- L1 3 turns no. 16, 3/4" diameter, tap down from hot end for best performance
- L2 3 turns no. 16, 3/4" diameter, tapped 3/8-turn from cold end
- L3 3 turns no. 16, 3/4" diameter, center tapped
- L4 3 turns no. 16, 3/4" diameter, tapped 1/8 turn from cold end

fig. 1. A tunable fet preamplifier for use on vhf TV. For higher performance on the high band (channels 7 through 13), additional stages identical to the second stage may be added.

occurs in the E layer of the ionosphere and creates momentary bursts of E skip. Meteor scatter bursts can last anywhere from a fraction of a second to over a minute and produce DX from about 1100 miles to as close as 180 miles. Most common are signals in the 500- to 900-mile range.

Best results can be expected during meteor showers, when large swarms of meteors enter the earth's atmosphere. (A list of showers can be found in *The Radio Amateur's VHF Manual*, published by the ARRL.) However, there are always sporadic meteors being pulled into the earth's atmosphere.

For TV-DX purposes, the best time for

showers, but on an average, the greatest activity is between midnight and noon.

With average equipment, a great deal of meteor scatter can be observed on the low band TV channels. For results at channel 7 or higher, stacked, cut-to-channel antennas and a low-noise preamp are required.

Lightning scatter (Ls) Lightning scatter is a very interesting and recently discovered mode of propagation. In fact, the discovery is so recent that almost no research has been conducted into its mechanics. This much is known — when very intense thunderstorms are between two points, perhaps from 200 to 500 miles

apart, they can reflect uhf signals between those points. Exactly how the signal is propagated, or why lower frequencies are not affected, has not yet been determined. It is believed that the first recorded observation of lightning scatter was made in June, 1968, by a TV-DXer. In September of that same year W5RCI and WØDRL made the first 432-MHz contact via lightning-scatter propagation.*

Reception during lightning-scatter propagation appears very much like that of meteor scatter. Signals pop in and out with varying strengths. I have even seen signals reach near snow-free levels for several seconds. If any readers have further data on lightning-scatter reception, I would very much like to hear from them.

equipment

Just as in amateur radio, how serious you are about the hobby will determine what caliber of equipment you use. At the bottom of the scale are the occasional TV-DXers, many of whom only choose to use indoor rabbit ears! This is fine for a touch of strong summer sporadic-E, but not much more.

On the average, most TV-DXers are using a quality consumer TV set and a broadband Yagi or log-periodic vee antenna. The antennas are usually fringe-area models.

For uhf reception a separate antenna, of any of a number of types, is mounted on the same mast. The array is rotatable and usually mounted anywhere from 30- to 50-feet above ground. Where overloading is not a consideration, mast-mounted vhf and uhf preamps may be used.

The more serious TV-DXer uses a separate Yagi or log-periodic Yagi¹ for the low and high bands. He often uses stacked antennas for increased gain, capture area and directivity. Single-channel

*The first recorded observation of lightning scatter propagation was described in the August, 1968, issue of the *VHF-UHF Digest*. The two-way 432-MHz lightning-scatter contact is discussed in "The World Above 50 MHz," *QST*, November, 1968, page 89.

antennas are also used for maximum results on a given channel. At vhf, low-loss RG-59/U cable (such as Belden Duo-Foil or International Interfoil 750) is used throughout. For the serious DXer, consumer-type preamps are now taboo because of their susceptibility to overload, the resulting cross-modulation, and

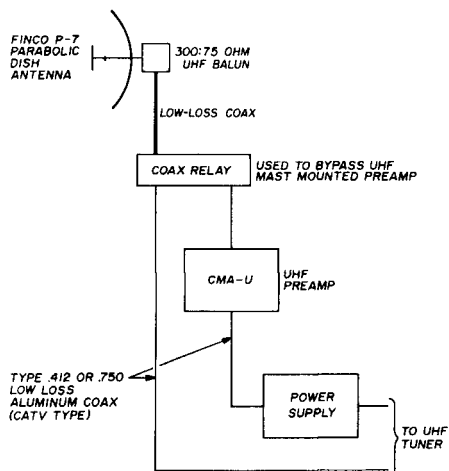


fig. 2. A typical high performance installation for DX reception of uhf TV stations.

poor noise figures. For the vhf TV channels the serious DXer uses a home built tunable, multi-stage fet preamp similar to the one shown in fig. 1. This preamplifier improves adjacent channel rejection and limits video bandpass as well as providing improved noise figure and high gain. Even though there are many tuning knobs, once the dials are calibrated, tuneup is quite fast.

On the uhf TV channels (470 to 890 MHz) a seven-foot parabolic dish antenna is a must. In the reasonable price range the Finco P-7 is about the best available. Once again, consumer type preamps are not used. Their noise figure is often no better than the uhf tuner or converter.

However, there are several CATV-type, broadband uhf preamps that *will* help. Here, the best buy is the Blonder-Tongue CMA-U. Unfortunately, in strong signal areas, overload and cross-modulation can

occur on these units as well. To combat this, I installed a remote 75-ohm coaxial relay, such as the Dow Key 77-2632, to switch the preamp in and out, as needed (see fig. 2).

The uhf antenna and, hopefully, the high-band antennas are mounted a minimum of 50-feet above ground. A minimum of 25-feet should do for the low band antenna. To combat other assorted local problems, the serious TV-DXer uses bandpass filters, tunable traps, attenuators, combine interdigital preamplifiers² and other devices.

The receiver is still generally a high

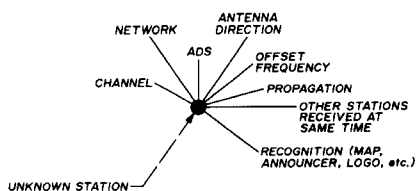


fig. 3. The identity of an unknown TV station can often be determined if there are enough pieces of information (see text).

quality consumer type, but a number of TV-DXers (myself included) have gone to more elaborate CATV-type receivers. These sets boast such features as manual rf gain controls, variable agc positions, video level controls, four i-f stages and other refinements. They do however, require the addition of a video monitor for visual display and an audio amplifier for sufficient audio to drive a speaker.

identifying unknown signals

Often, the TV-DXer finds it necessary to play Sherlock Holmes in an attempt to identify an unidentified signal. Searching for clues, he tries to fit the pieces of the puzzle together. Fig. 3 illustrates some of the required considerations. If enough clues point to one station being the prime suspect, the TV-DXer makes his decision. However, as any good detective or DXer knows, you must not jump to conclusions with insufficient evidence!

One consideration is called *offset*. This refers to whether a station is assigned to

be exactly on channel or is offset, 10-kHz high or 10-kHz low of center. The FCC assigns offset frequencies to minimize co-channel interference. As a side benefit of this, the offset patterns produced when two stations beat against each other can reveal valuable information about one of the stations.

For example, if you are receiving a known station (call it A) on channel 12 and see another station (X) beating against it, you can determine the offset frequency of station X by the offset pattern observed. From a station list, you can determine that station A is assigned to operate on -12.* If the heterodyne of co-channel station X is producing many fine horizontal lines, station X is 20 kHz away (+12). About 10 or 15 larger bars indicates a 10-kHz separation (12 exactly); 5 or 6 still thicker bars indicates zero offset (-12). Thus, if the reference station (A) has a plus or minus offset, you could see any of three possible patterns from an interfering station. However, if station A is exactly on channel, you would see only two patterns (zero and 10 kHz).

Offset lists are not 100% accurate partially because of allocation changes, typographical errors and carrier drift (beyond FCC allowances). Most of the time however, offsets can greatly help in adding another piece to the puzzle.

Time zones are not listed in fig. 3 because many stations delay their broadcasts. This could give you a false impression that a station is farther, or closer (depending on whether you're located in the East or West) than it actually is.

The *VHF-UHF Digest*, described later, features a column devoted to helping TV-DXers decide just what they received.

**Broadcasting Yearbook*, available from *Broadcasting Magazine*, 1735 De Sales Street, NW, Washington, DC 20036, lists all U.S. Television, fm and a-m stations (including tv offset frequency information). The *WTFDA TV Station Guide*, priced under \$5.00, available from WTFDA, Box 163H, Deerfield, Illinois 60015, provides complete listing of U.S. tv stations by channel.

The DXer sends a detailed report of his reception to the column editor, who in turn scans *TV Guides* from around the country. If the editor comes up with a blank too, the report is printed in the hopes that another DXer will recognize the logging and its origin.

confirmations

Amateurs and radio broadcast stations are not alone in receiving QSL requests. Many TV-DXers send their reception data to TV stations and request a written verification. Most stations do verify, and now many TV stations even have their

DX stations as instant proof of reception. The photos are also great for making believers out of skeptics.

It's a simple matter to photograph TV-DX once you know the basics. If your camera has a leaf-type shutter, a setting of 1/30 second at around f/5.6, using Kodak Tri-X film, usually works out well. For cameras using a focal-plane shutter, try 1/8 second at f/8.

Sight and focus the camera so that the entire screen is clearly in view. *Never* use flash, the light bounces off the face of the picture tube, giving you an obliterated photo. For the same reason, reduce the amount of external light striking the screen as much as possible. To prevent camera motion, the use of a tripod is highly recommended.

A highly detailed 8-page booklet entitled, "Photographing Television Images," is available free of charge from the Eastman Kodak Company (Consumer Markets Division, Rochester, New York 14650). Just request Kodak Customer Service Pamphlet AC-10. This booklet describes photographing black-and-white and color TV images using a variety of cameras including movie cameras.

One trick you won't find listed in the Kodak pamphlet is how to turn snowy pictures into clear ones. By using a time exposure of 1/2 to several seconds, you can clear the snow out of a weak picture. Remember to adjust your exposures accordingly. If you have a lightmeter it can be used effectively for TV images as well. As with all forms of photography, practice will improve your results.

vhf amateur applications

Unless you're already too intrigued with TV-DXing itself, you've probably started to think about its amateur applications. The most obvious of these is as a propagation monitor. You may notice the effects of a vhf opening on your TV set before you even turn on your vhf rig. And secondly, once operating, TV-DX observations can aid in determining the geographic coverage of an opening. When used in conjunction with an fm broadcast

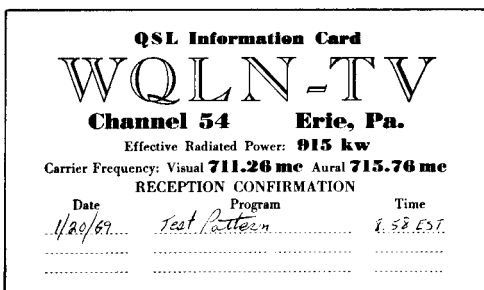
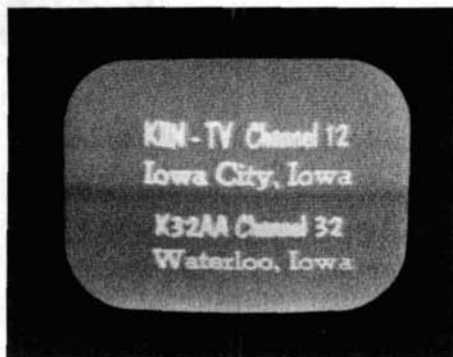


fig. 4. QSL card is typical of many used by other TV stations. This card is signed on the reverse side by Assistant Chief Engineer, WA3DLS.

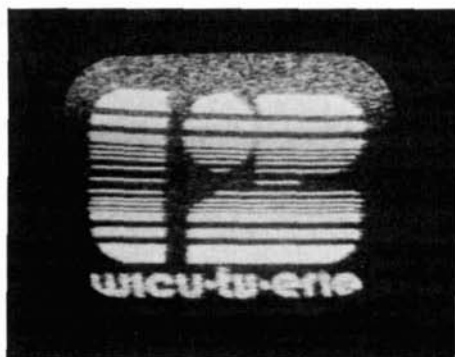
own printed QSL cards. The chief engineer is usually the "verie signer" and he's often a fellow ham. Most veries (verifications) are still typewritten letters and often carry some rather amusing reading. Such lines as, "We hope you will continue watching our station," "This will verify receipt of your report," and, "We wish you were one of our regular viewers," pop up frequently. There's even the occasional, "No, you would not have been able to receive our station, because our new antenna transmits no sky waves."

photographing TV-DX

Perhaps this section should be subtitled, "how to get an instant QSL." What better souvenir of a DX logging could you have? TV-DXers have long been known to photograph test patterns and ID slides of



Reception is of KIIN-TV, channel 12, Iowa City by tropo. 210-miles distant.



WICU-TV, Erie, Pennsylvania. 400-mile reception by tropo.

radio, these observations can also help monitor the muf. One practical application of this technique is to determine

and a high-gain parasitic array. A TV set will also work out quite well if it is used with a low-noise channel-7 mast-mounted



KTVC, channel 6, Ensign, Kansas. Received by sporadic-E at 725 miles.



Another sporadic-E catch KACB-TV, San Angelo, Texas. Two offset patterns are seen in this photo. The large black bars indicate zero offset, and the fine lines, a 20-kHz pattern. 1010-miles distant.

whether and when 2-meter sporadic-E is likely. The same is also true of auroral DX.

Several avid 2-meter meteor-scatter enthusiasts have realized that they can stay one step ahead by monitoring the activity on channel 7. As a meteor enters the earth's atmosphere, its ionized trail starts small and rapidly grows longer. Therefore, the trail more readily reflects higher than lower frequencies. In short, a meteor burst is very often heard on TV channel 7 just before it's heard on 2 meters.

For this application, there are two possible easily duplicated monitoring systems, a low-noise crystal-controlled converter tuned to about 179.25 MHz



Reception is of KOTA-TV, channel 3 in Rapid City, South Dakota, by sporadic-E. Note the fine lines indicating 20-kHz offset co-channel interference. 785-miles distant.



WCET, channel 48, Cincinnati, Ohio. A 255-mile tropo path.



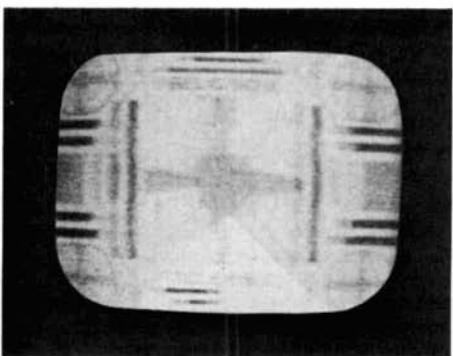
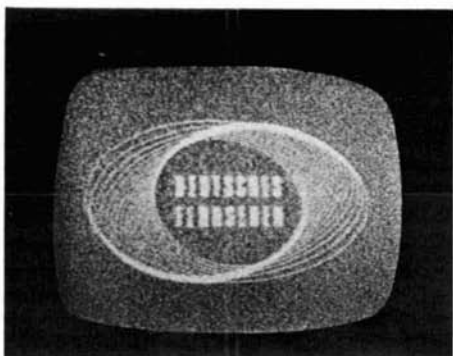
Sporadic-E reception of CBHT-TV, Halifax, Nova Scotia. 1189-miles distant.

preamp.* In fact, with a TV receiver, you stand a good chance of identifying the station bursting in. Either way, the single-channel mast-mounted preamp is a great asset.

If you're looking for a vhf field-day site, a battery-powered TV set can be

your best friend. It will aid in determining how good a location is for vhf reception. Monitor some of your fringe stations at each trial site. You may find that results can be greatly enhanced by moving only a small distance.

Whenever I start thinking about the



TV-DX is also popular in Europe. These photos were taken by a DXer in Holland. Top: A.R.D., West Germany, by tropo. Bottom: Belgium by tropo on channel E2.



KS2XBR, channel 38, Chicago, is one of the last experimental TV stations in the United States. This station is operated by Zenith Radio for testing pay TV devices. Truly a rare catch.

correlation between TV-DX and 6-meter propagation, I can't help remembering a rather intense sporadic-E opening that occurred several years ago. While TV DXing on channel 3, I began to hear some TVI over the TV-DX station from an

*The CADCO IPA-HB28/7 preamp is probably the unit best suited to this purpose. The noise figure of this preamp is under 1.5 dB and gain is 28 dB. Information on this preamp is available from CADCO, Inc., Box 18904M, Oklahoma City, Oklahoma 73118.

amateur in California. As if hearing double-hop TVI wasn't enough of a shock, I discovered that his signal was stronger on the TV than on 6 meters! I dropped this fellow amateur (who shall forever remain unnamed) a note, and received a reply written on the back of a QSL card. The reply stated that I was about the 50th person to complain about



Author's home station is used for TV-DX as well as for amateur communications. Note CATV-type TV monitor in upper right.

his TVI — the other 49 were his neighbors. Anyway, I was the one to finally convince him that his neighbor's TV sets weren't at fault!

TV-DX club

In the United States there is one organization devoted to TV, fm and vhf utility DX — The Worldwide TV-FM DX Association. Monthly, WTFDA publishes the *VHF-UHF Digest* which features columns devoted to member's DX reports, FCC and CRTC news, theory, construction, statistics (DX records), QSLs and

*A one-year membership in the WTFDA is \$7.00 and includes 12 monthly issues of the *VHF-UHF Digest* (for first-class mail delivery of the *Digest* the annual dues are \$9.00). Sample copies of the *VHF-UHF Digest* are available for 50 cents each, postpaid. Rates for subscribers outside the United States are available upon request. Write to the WTFDA, Box 163-H, Deerfield, Illinois 60015.

others. Feature articles frequent the winter issues. You might say that WTFDA serves the same function for non-amateur VHFers as the ARRL serves for amateur radio operators. WTFDA even holds annual conventions. This non-profit group strives at promoting vhf and uhf research and technical advancement and prides itself on its very devoted members.*

Mel Wilson, W2BOC, is a WTFDA member and credited the organization with providing detailed sporadic-E reports in the *VHF-UHF Digest*. These reports provided Mel with hard data to add to his 30+ years of propagation research.

Also well known in vhf circles for his propagation studies is Pat Dyer, WA5IYX. Pat is WTFDA's "VHF Utility DX" editor. His column covers just about every form of non-broadcast, non-amateur DX above 30 MHz. By reviewing reports in Pat's column, it is easy to follow the rise and fall of the F2 muf.

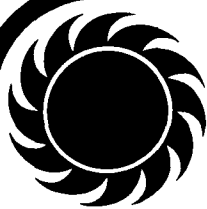
Whether or not your main interest in amateur radio lies in vhf, during the coming spring and summer months I hope that you'll keep one eye on those empty TV channels. Who knows, maybe you'll lock onto some TV-DX and get hooked, the way I did!

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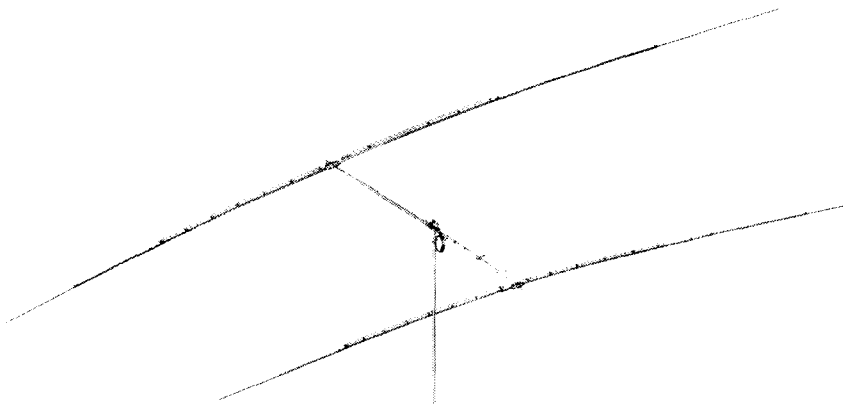
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how to select batteries

for portable equipment

A discussion of
the performance
and size and cost
characteristics of
the many types
of batteries
currently available

John Nelson, WBØAIK, 700 35 Street, No. 288, Marion, Iowa 52302

Inexpensive transistors and multifunction integrated circuits have made possible a whole new generation of portable and low-power equipment for the radio amateur. They have also relieved many construction headaches for the ham who builds his own equipment. One of those headaches used to be power supply construction, but now batteries are the most popular power source because of their simplicity, low cost and portability. However, whether you build or buy your equipment, one big problem remains — selecting the batteries. The selection process may be rather involved, particularly for the builder, who has more options open to him.

battery characteristics

The first step in selecting a battery is to determine in detail the power requirements which the battery system must meet. You also should have an idea of which requirements are most important. This can be illustrated by example: Suppose you are building a portable transmitter which will use a 9-volt dc power supply. It will draw about 100 mA while transmitting and 30 mA while receiving. A list of battery parameters, in order of their importance, might look like this:

Battery voltage. This is first on the list for obvious reasons. There isn't much point in examining all the available 24-volt batteries when you only need 9 volts. But even this important parameter isn't as straightforward as a first glance might indicate. Since the output voltage of a

battery declines with operating time, you must specify the minimum and maximum supply voltages the transceiver can tolerate. Let's say that 7.2 to 10.0 volts is acceptable.

Power capability. This is almost as important as battery voltage. If the battery simply will not deliver 100 mA, it cannot be considered.

Cost. Although we all want to stretch a dollar as far as we can, you must weigh the expected battery life against its initial cost.

Size/weight. The importance of a battery's bulk will vary with the type of operating you do and the size of the radio itself. In the case of the example, you may want to trade off increased size and weight for decreased cost, if necessary. You should, however, try to stay under six pounds and 100 cubic inches.

Battery life. The economics of this parameter are covered above, but the length of time between replacements or recharges is also a matter of convenience. You may want to operate for most of a weekend without worrying about the battery giving out.

Availability. If you choose a battery type which must be replaced frequently, you must be sure that replacements are easily obtained.

Others. Some other battery parameters which are not important for the example are high and low temperature characteristics, ease of storage and long shelf life.

examining available alternatives

Let's see what is available to choose from. Since the *carbon-zinc* battery or Leclanché cell is the most widely used type of battery, and usually the least expensive, look there first. Many of the 9-volt carbon-zinc batteries are not capable of supplying 40 to 50 mA, average, for any appreciable length of time. (Estimates of battery life are based on 50 mA average current, which would correspond to transmitting for about 30% of the operating time.) One battery that will is

the Eveready 716 or the equivalent Burgess 4F6H — it should supply the transceiver for more than 300 hours. However, this battery costs over eight dollars, weighs 8½ pounds, and occupies over 200 cubic inches of space.

Another approach would be to use six common D-size flashlight cells in series. This could be the cheapest approach, but you would get less than 80 hours of battery life and battery volume would go up to about 340 cubic inches.

While I am discussing carbon-zinc batteries, I should mention the possibility of recharging them. Although such recharging can be done, it is probably not practical, and can be dangerous. Excessive gassing may result from too high charging current and the cell could explode. The following is an excerpt from National Bureau of Standards Letter Circular LC 965:

"From time to time attention has been turned to the problem of recharging dry cells. Although the dry cell is nominally considered a primary battery it may be recharged for a limited number of cycles under certain conditions. Briefly these are:

1. The operating voltage on discharge should not be below 1.0 volt per cell when battery is removed from service for charging.
2. The battery should be placed on charge very soon after removal from service.
3. The ampere-hours of recharge should be 120 - 180% of the discharge.
4. Charging rate should be low enough to distribute recharge over 12 - 16 hours.
5. Cells must be put into service soon after charging as the recharged cells have poor shelf life.

Recharging of dry cells may be economically feasible only when quantities of dry cells are used under controlled conditions with a system of exchange of used cells for new ones already in practice, and with equipment available to

provide direct current for charging. Such a system would not be practical for home use."

mercury batteries

It looks as though carbon-zinc batteries could satisfactorily fulfill the transceiver power requirements, but let's see what else is available. What about *mercury* (mercuric oxide) batteries? They

explosions. Apparently, mercury batteries will not fulfill the requirement.

alkaline batteries

The *alkaline* (alkaline-manganese) battery is becoming increasingly popular both because of its higher service capacity and because many types are rechargeable. Although the alkaline-manganese cell has the same 1.5-volt open-circuit cell voltage

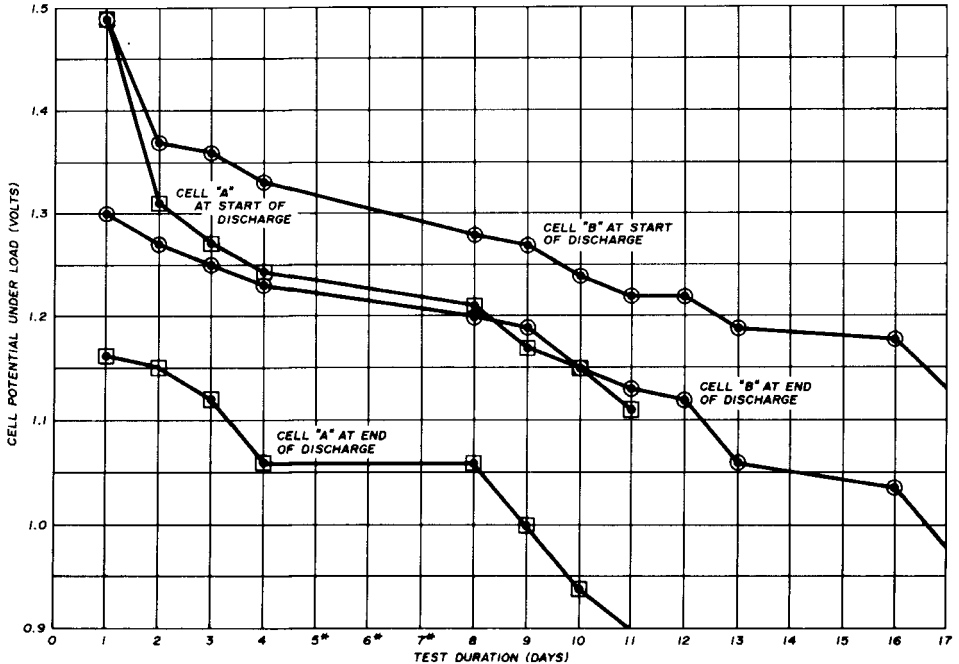


fig. 1. Comparison of two 1.5-volt carbon-zinc cells, discharged 3½ hours per day into a 10-ohm load. Cell A is a low-cost unit while Cell B is a so-called super cell, manufactured by a well-known company. On days marked with an asterisk the cells were not discharged.

have the advantages of a very stable cell potential and high power capability for a smaller size. They are also expensive.

Since a single 9-volt battery of sufficient power capacity is not readily available, let's look at six D-size cells (such as the Eveready E42) in series. Here you could approach 300 hours of operation, but at a cost of about thirty dollars and with a volume exceeding 300 cubic inches. Although it is possible to recharge mercury cells, decreasing the overall operating cost, manufacturers discourage the practice because of the danger of cell

as the carbon-zinc cell, it discharges at lower voltages. The carbon-zinc cell provides most of its available energy above 1.25 volts and will be just about exhausted at 1.0 volt. However, the alkaline-manganese cell yields most of its energy below 1.25 volts and still has quite a reserve below 1.0 volt.

This means that if you use six alkaline-manganese cells for the 9-volt transceiver power supply, you should expect a significant percentage of operation to be at 6 volts or less. Such a supply voltage drop would not be acceptable for the

transceiver in the example. However, if the system is to be recharged, discharge is usually terminated at about 1.1 volts. Thus, a rechargeable alkaline battery system would provide acceptable operating voltages.

I found no readily available 9-volt alkaline batteries, but rechargeable 1.5-volt D-cells are easily obtained. Six of these cells should cost about ten dollars

might be expected, all these good things do not come cheap. Nickel-cadmium D-size cells for use in the transceiver would cost over six dollars each, and would be just as bulky as the other types.

Another alternative would be to use a 10-volt nickel-cadmium battery such as the Eveready 1007 power pack. This unit weighs less than 4 pounds and only takes up about 63 cubic inches of space. For

table 1. Performance and cost of batteries used for a 9-volt power supply.

type	size (cubic inches)	weight (lb.)	estimated life (hours)		cost	
			per charge	total	initial	per 100 hours
9 volt carbon-zinc (Eveready 716, Burgess 4F6H)	204	8½	310	310	\$ 8.95	\$ 2.90
Six 1.5 volt carbon-zinc D cells	345	1½	280	280	\$ 1.50	\$ 1.90
Six 1.35 volt mercury D cells	345	3	280	280	\$30.00	\$11.00
Six 1.5 volt alkaline recharge- able D cells	345	2	40	2000*	\$10.00	\$.50
10-volt nickel- cadmium (Eveready 1007)	63	4	80	40,000†	\$40.00	\$.10

*Based on an estimated 50 cycle life

†Based on an estimated 500 cycle life

and should last 30 - 40 hours between recharges. If battery life is 50 recharge cycles, then the initial investment should be good for nearly 2000 hours. The recharge operation can be simplified by purchasing one of the special chargers which are generally available for less than ten dollars. Size and weight are about the same as carbon-zinc D-cells. Rechargeable alkaline batteries are definitely among the possibilities for powering the transceiver.

nickel-cadmium batteries

When you discuss rechargeable batteries, everybody thinks of *nickel-cadmium* batteries. This popular battery has led to the development of a tremendous variety of cordless, rechargeable devices because they combine the ease of portability with the freedom from having to buy fresh batteries everytime you turn around. As

operation between 9.0 and 10.0 volts, capacity between recharges would be about 80 hours. The initial cost of nearly forty dollars sounds pretty steep until you realize that the recharge cycle life of this unit is upwards of 500 cycles if care is taken to avoid over-discharge and if recharging is performed regularly. This represents over 40,000 hours of available power!

Recharging is easily accomplished with the aid of the Eveready 1807 charger, available for under ten dollars. Depending upon your store of ready cash and your eye for long-haul economy, this type of battery system could be the best selection.

lead-acid batteries

One other battery which should be mentioned is the familiar automotive-

type *lead-acid* battery. It has the advantage of being readily available and easily recharged for many, many cycles. Although it may be useful for some semi-portable or mobile applications, I would not seriously consider it for the example transceiver because of its objectionable bulk and messy liquid electrolyte.

making the choice

Looking at **table 1**, it is easy to see that the selection must be based on

getting a better cell than the cheaper *Brand X*?

To satisfy my own curiosity I bought two cells and conducted a simple test. Cell A was sold under the name of a popular discount department store at 34 cents for a pair. Cell B was a *Super Cell* manufactured by one of the well-known battery companies. It had 39 cents stamped on one end but was purchased in the same store for 48 cents per pair.

The test consisted of discharging the

table 2. Battery manufacturers. Most of these firms will provide information on the performance and recommended use of their batteries.

General Electric Co.
Battery Products Division
P.O. Box 114
Gainesville, Florida 32601

Mallory Battery Company
Broadway and Sunnyside Lane
Tarrytown, New York 10591

Gould, Inc.
Burgess Division
P.O. Box 3140
St. Paul, Minnesota 55165

Sonotone Corp.
Battery Division
Saw Mill River Road
Elmsford, New York 10523

Gulton Industries, Inc.
Battery and Power Sources Division
212 Durham Avenue
Metuchen, New Jersey 08840

Union Carbide Corp.
Consumer Products Division 270 Park Avenue
New York, New York 10017

tradeoffs. The problem seems to reduce to choosing between six carbon-zinc D cells and the 10-volt nickel-cadmium power pack. In the case of the carbon-zinc D cells you get the lowest weight, least initial cost and a reasonable cost per hour. In the case of the nickel-cadmium power pack you get the smallest size and lowest extended cost per hour.

Which is best? That depends on your particular circumstances. For the transceiver let's choose the six carbon-zinc D cells, trading off increased bulk and higher long-term cost for the small initial cost. **Table 1** also indicates that rechargeable alkaline D cells would be an attractive compromise selection.

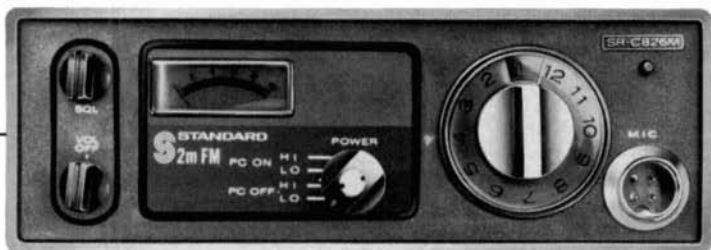
The selection process is now almost complete. The friendly neighborhood drugstore has several different brands and prices from which to choose. If you pay a premium for the *Super Long-Lasting Heavy-Duty Power Cell* are you really

two cells into ten-ohm loads for about 3½ hours each day. Cell voltages were measured at the beginning and end of each discharge period and are displayed graphically in **fig. 1**. Note the recovery in cell potential after the cells are "rested." You can see from **fig. 1** that cell B will last more than twice as long as cell A and is therefore the better buy in this case. In general, it probably pays to buy the more expensive batteries, even if only for the convenience of less frequent replacements.

conclusion

It should be obvious from this discussion that one of the requirements for intelligent battery selection is sufficient information on the available choices. **Table 2** lists the names and addresses of several battery manufacturers from which further information may be obtained.

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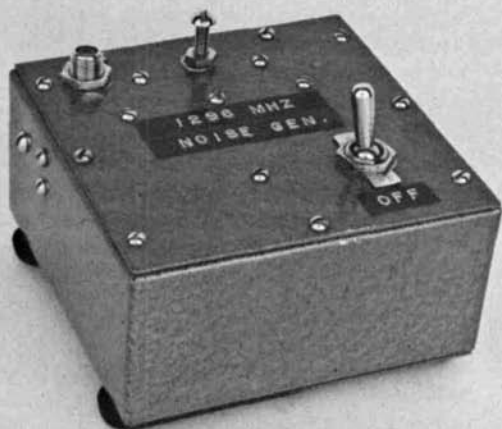


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1296-MHz noise generator

Construction details
for a simple diode
noise generator
for optimizing
receiver performance
on 1296 MHz

Cy Dirickson, W3BSV, 714 South Park Drive, Salisbury, Maryland

A **noise generator** is an extremely useful item to have around the shack for checking out your latest uhf preamplifiers or converters. This is particularly true on 1296 MHz where best low-noise performance must be obtained for practical, long-distance communications. The noise generator can also be used to check coaxial cable loss and transmit-receive relay loss by simply reading the values from your receiver's S-meter.

The output of the simple 1296-MHz noise generator described here is just

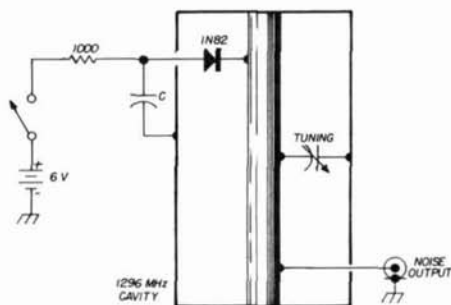


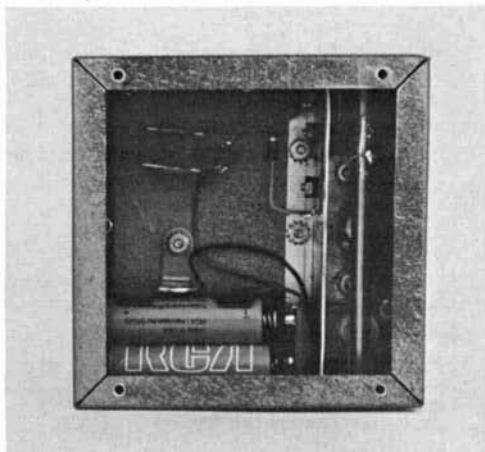
fig. 1. Simplified schematic of the 1296-MHz noise generator. Construction details are shown in fig. 2.

detectable on the average 1296-MHz mixer, and when fed through a K5200/K5500 rf amplifier, will show a gain of three S-units above internal noise. This represents approximately 18 dB.

construction

The 1296-MHz noise generator is built into a Bud 4x4x2-inch aluminum chassis with a bottom plate. All but one wall of the 1296-MHz trough line are provided by the chassis; the remaining partition is made from thin brass or copper sheet and attached to the chassis with 6-32 screws.

Both ends of the 1/4-inch brass rod used in the cavity are drilled and tapped for 6-32 screws. This rod is mounted in the center of the trough line with 6-32 screws, as shown in fig. 2. The 1N82 noise diode is tapped 1-inch down from



Construction of the noise generator.

the top of the line. The output BNC connector is connected to the bottom of the line with a 1/4-inch wide copper strap, 1-inch long. The copper strap runs parallel to the line as shown in the construction diagram.

Although the BNC connector is shown on the side of the cavity for the purposes of this diagram, it is actually located underneath the trough line, directly opposite the 8-32 tuning screw.

The 8-32 tuning screw runs through a nut which is soldered to a thin, 2x3/4-inch brass plate which is attached to the aluminum chassis with screws. An 8-32 nut is used as the tuning disc. Another 8-32 nut is used for locking the tuning screw after the noise generator has been adjusted for maximum output at 1296 MHz.

The bypass capacitor consists of a 1-1/2x1-inch piece of thin brass, folded over into a U-shape and soldered to the side of the inside partition. Another small piece of brass sheet, about 1-inch square, is inserted into the U-shaped piece, as shown in fig. 2. Thin teflon sheet is used for the dielectric.

Power to the noise diode is provided by four 1-1/2-volt penlight cells, mounted in a compact battery holder. The spst toggle switch is mounted on the top of the enclosure.

ham radio

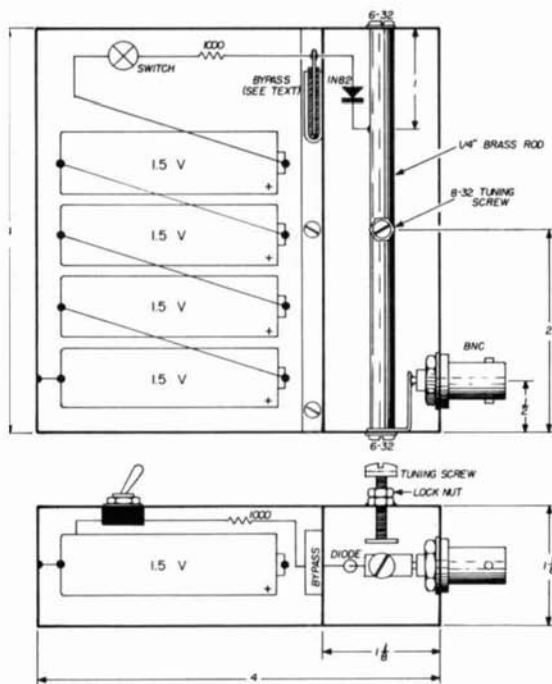
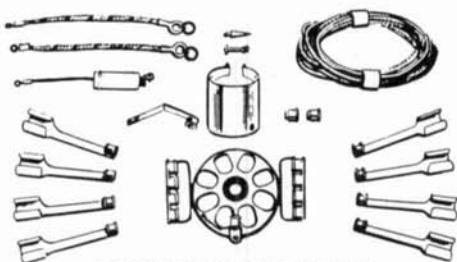


fig. 2. Construction of the 1296-MHz noise generator. Output BNC connector is actually located underneath the trough line, opposite the tuning screw, but is shown on the side, here, for clarity.

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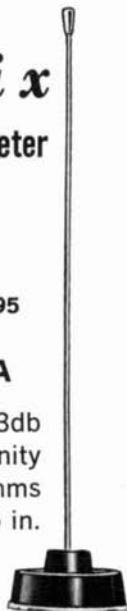
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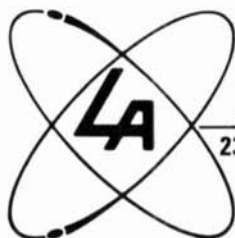
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How to obtain
sixteen vhf
fm channels,
spaced 30 kHz,
with only four
inexpensive crystals

Jim Fahnestock, W0OA, Box 1355, Evergreen, Colorado 80439

One of the not-so-hidden expenses in two-meter fm operation is the cost of crystals. For 12-channels in some transceivers, the cost of crystals is nearly as much as the cost of the transceiver itself! And, on occasion, your desired operating frequency may *not* be among the 12 channels that cost so much to acquire.

The frequency synthesizer described here can produce 16 fm channels, spaced 30 kHz, with just *four* inexpensive crystals. With nine crystals all 36 channels from 145.98 to 147.03 can be synthesized. In addition, a five-crystal receiver local-oscillator synthesizer is suggested, covering all channels from 146.34 to 147.06 in 30-kHz steps.

The concept is quite simple, though different from (and much simpler than) conventional synthesizers. The idea has been *tried* on paper and appears to present no difficult problems. At the time of this writing a number of construction projects are in the works using ICs. One circuit uses four ICs, four crystals and two simple filters to produce 16 channels for repeater inputs. Another circuit uses eight crystals to provide 32 channels, permitting repeater *or* simplex operation on all commonly-used channels — and then some.

transmitter synthesizer

The basic block diagram of the transmitter synthesizer is shown in **fig. 1**. With

four crystals, all channels from 145.98 to 146.43 are covered, providing inputs for most repeaters with a transmitter that multiplies 24 times.

The upper half of table 1 shows the operating frequencies provided by the circuit of fig. 1. With five extra crystals, F_E through F_1 , all channels from 145.98 to 147.03 are available in 30-kHz steps.

An alternate eight-crystal version is shown in fig. 2 and the available transmit-

obtain the 24th subharmonic of the desired operating frequency. Multiplication is done in conventional fashion in the transmitter. The synthesizer simply serves as a substitute for the usual transmit crystals.

For example, suppose a frequency of 146.34 is desired. Referring to fig. 1 and table 1, this choice calls for mixing the fundamental of crystal D ($F_D = 8.130$ MHz) with the 4th subharmonic of crystal D ($F_1 = 8.130/4 = 2.0325$ MHz). The mixer extracts the *difference* between these two frequencies, $8.130 - 2.0325 = 6.0975$, which, when multiplied 24 times in the transmitter, yields the desired output frequency, $6.0975 \times 24 = 146.34$ MHz.

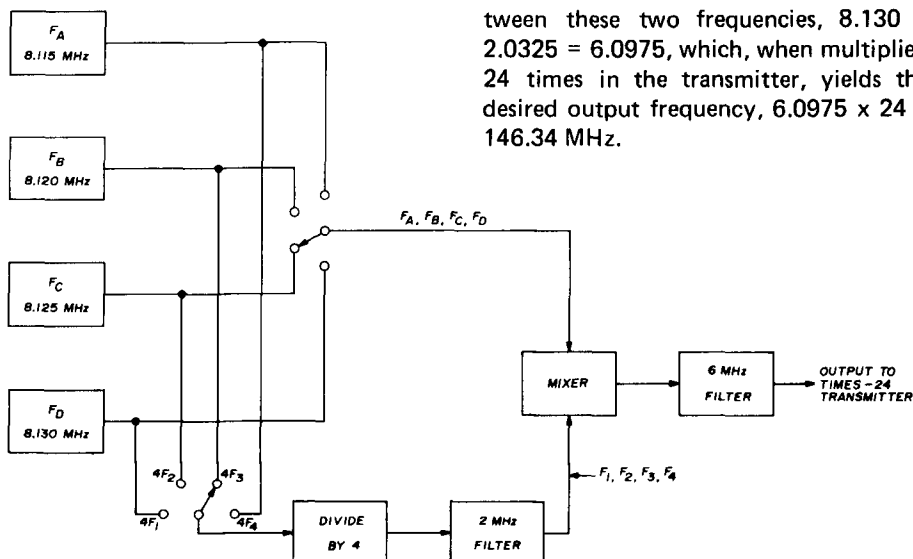


fig. 1. Suggested circuit for a 4-crystal, 16-frequency synthesizer to cover repeater input channels from 145.98 to 146.43 MHz. See table 1 for frequency combinations.

ting frequencies include all but 146.46 through 146.55 MHz. In fig. 2, the operating channels would be from 146.58 to 147.03 (16 channels) and the transmitter would be set to transmit *on channel* or 600 kHz below for repeater operation, simply by setting the *repeat simplex* switch in the appropriate position.

As shown in fig. 1, one crystal fundamental frequency is mixed with the fourth subharmonic (easily obtained with a single dual-JK flip-flop) of either the same or one of the other crystals to

The sixteen possible combinations of the four crystal frequencies and their 4th subharmonics provide the 16 repeater input channels as shown in table 1. Using 4th subharmonics of the same four crystals, but fundamentals of those shown in the simplex position, fig. 2, simplex operation is available.

Fortunately, 8-MHz crystals are inexpensive and easy to use. Garden variety crystals can be *rubbered* to the correct frequency in a variety of ways. If a high-frequency digital counter is available either the fundamental or the fourth

subharmonic of each crystal can be measured and adjusted. An accurate receiver or frequency meter capable of tuning 8 MHz or 2 MHz can also be used.

Notice that crystal D ($F_D = 8130$ kHz) can be set by the discriminator of a 146.34-MHz receiver since it is the only

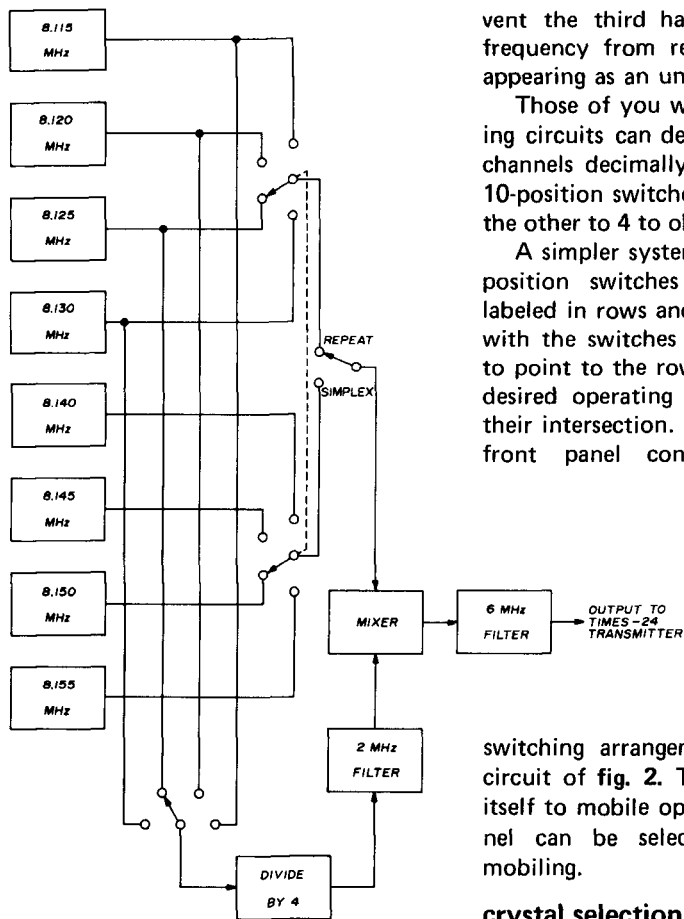


fig. 2. Circuit for repeater and simplex operation uses eight crystals for 32 transmit channels.

crystal used in generating that frequency. Likewise, crystals C, B and A can be adjusted with receivers on 146.25, 146.16 and 146.07 MHz. If the receivers are on frequency, all the other frequencies will be.

It should be noticed that all 16 frequencies are the result of either one or

two crystals. This may require that two oscillators be operating simultaneously. Obviously, good isolation must be provided between oscillators to prevent the fundamental of the crystal whose 4th subharmonic is being used from reaching the mixer and producing a spurious signal.

The 2-MHz filter is necessary to prevent the third harmonic of the 2-MHz frequency from reaching the mixer and appearing as an unwanted 6-MHz output.

Those of you who are adept at switching circuits can design a system to select channels decimally, that is, to have two 10-position switches, setting one to 3 and the other to 4 to obtain 146.34 MHz.

A simpler system would use two four-position switches and a printed card labeled in rows and columns as in table 1 with the switches arranged mechanically to point to the row and column with the desired operating (receive) frequency at their intersection. Fig. 3 shows a possible front panel configuration using the

switching arrangement suggested in the circuit of fig. 2. This arrangement lends itself to mobile operation since the channel can be selected by "feel" while mobiling.

crystal selection

At first glance, it might seem that the selection of crystal frequencies was somewhat arbitrary. However, there is just one set of frequencies that will give the desired operating frequencies and channel spacing for a given transmitter multiplication factor.

Several conditions must be met simultaneously. First, the *difference* between the selected fundamental frequencies and selected 4th subharmonic frequencies must be 1/24th the operating frequency

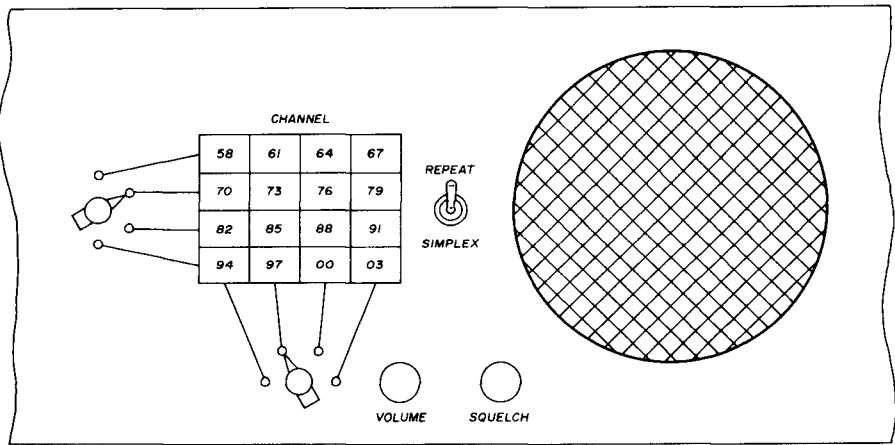


fig. 3. Suggested front panel layout for 32-channel transceiver shown in fig. 2.

for a 24 times transmitter. Second, the crystal subharmonic frequency *steps* must equal the desired channel spacing divided by the multiplication factor; since these frequencies are derived from the crystal fundamental frequencies, this determines the steps required of the crystal frequencies.

Since the goal is 30-kHz spacing in the 146-MHz region, the crystal subharmonic frequencies must be spaced $0.03/24 = 0.00125$ MHz. The fundamentals must be spaced four times that, or 0.005 MHz.

The lowest operating frequency (in this case 145.98 MHz) will result from mixing the *lowest* crystal fundamental frequency with the *highest* subharmonic

(the *difference* between the two determining the transmitting frequency). Crystal frequencies can be computed as follows:

$$F_A - \frac{F_D}{4} = \frac{\text{Lowest Frequency}}{\text{Multiplication Factor}} \quad (1)$$

Since the crystal fundamental frequencies must be spaced 0.005 MHz, and there are three *spaces* between F_A and F_D , then

$$F_D = F_A + 3 \times 0.005 = F_A + 0.015 \quad (2)$$

using this value for F_D in eq. 1 yields

$$F_A - \frac{(F_A + 0.015)}{4} = \frac{145.98}{24}$$

Solving for F_A , we obtain the 8.115

table 1. Transmitting frequencies for combinations of fundamental and 4th subharmonic frequencies. Four-crystal version covers channels above dashed lines. Eight-crystal version covers all channels except those between dashed lines. Nine-crystal version covers all channels from 145.98 to 147.04 MHz.

crystal frequencies	$F_1 = \frac{FD}{4} =$ 2.0325 MHz	$F_2 = \frac{FC}{4} =$ 2.03125 MHz	$F_3 = \frac{FB}{4} =$ 2.030 MHz	$F_4 = \frac{FA}{4} =$ 2.02875 MHz
$F_A = 8.115$ MHz	145.98	146.01	146.04	146.07
$F_B = 8.120$ MHz	146.10	146.13	146.16	146.19
$F_C = 8.125$ MHz	146.22	146.25	146.28	146.31
$F_D = 8.130$ MHz	146.34	146.37	146.40	146.43
		see text		
$F_E = 8.135$ MHz	146.46	146.49	146.52	146.55
$F_F = 8.140$ MHz	146.58	146.61	146.64	146.67
$F_G = 8.145$ MHz	146.70	146.73	146.76	146.79
$F_H = 8.150$ MHz	146.82	146.85	146.88	146.91
$F_I = 8.155$ MHz	146.94	146.97	147.00	147.03

MHz shown in **table 1**. Frequencies F_B , F_C and so on are obtained by successively adding 0.005 MHz for each fundamental frequency. To add the channels 146.46 through 146.55, a fundamental crystal of 8135 would be added with appropriate switching provisions.

It will be noticed that only subharmonics of F_A through F_D are used. You might be tempted to try a 5x5 matrix (or even a 6x6) to obtain additional channels with fewer crystals, but the frequencies

table 1. No measurements have been made to determine the coupling between circuits. The 7473 dual-JK flip-flop makes an ideal divide-by-4 circuit and provides sufficient output to be heard in a Drake R4-A receiver equipped with a crystal for the 2.0- to 2.5-MHz band. Frequencies thus checked were right on.

The 2-MHz filter will probably consist of a parallel tuned circuit at 2 MHz and possibly a 6-MHz parallel circuit in series with the lead to the mixer to prevent the 3rd harmonic of the 2-MHz signal from reaching the mixer (the output of the divide-by-4 circuit is a square wave and will be rich in harmonics, suggesting careful attention to this potential source of spurious signals).

receiver frequency control

Naturally, the question arises, what about the receiver? There are several possible approaches. Probably the most simple is a tunable receiver (remember those?) with which the operator "finds" the repeater output or the 24th harmonic of a simplex frequency output, possibly with a *tune*

position that activates only the synthesizer.

The circuit of **fig. 5** illustrates another possibility. Here, the output of the synthesizer is multiplied 8 times (assuming a receiver with a local oscillator multiplication factor of three) and mixed with a crystal-controlled oscillator whose frequency is

$$F = \frac{F_{if} - F_{ro}}{3} \quad (3)$$

Where F_{if} is the first intermediate frequency of the receiver and F_{ro} is the

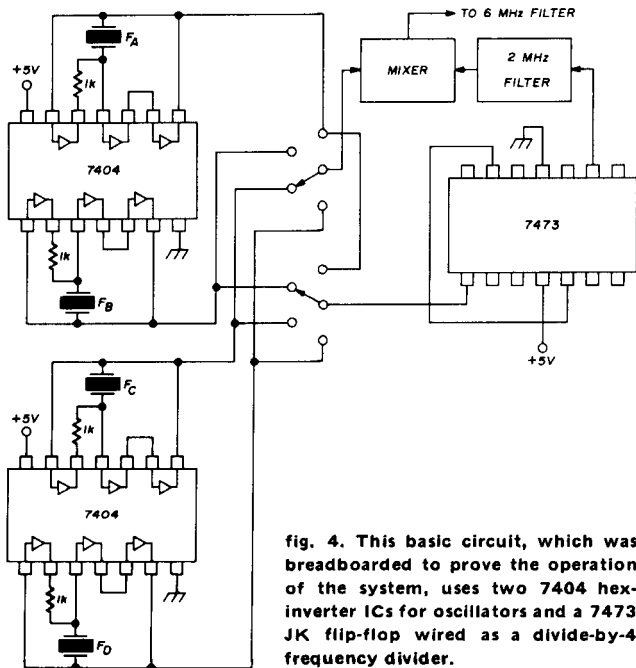


fig. 4. This basic circuit, which was breadboarded to prove the operation of the system, uses two 7404 hex-inverter ICs for oscillators and a 7473 JK flip-flop wired as a divide-by-4 frequency divider.

become unwieldy and mixing problems arise. Getting 36 crystal-controlled channels with only 9 crystals isn't a bad compromise!

practical circuit

With no IC experience and even less equipment, I have managed to implement some of the functions illustrated in the foregoing block diagrams using readily-available and inexpensive ICs (see **fig. 4**). The 7404 hex inverter affords two oscillators in the circuit shown using series-resonant crystals of the values shown in

table 2. Frequencies for receiver synthesizer using 10.7-MHz i-f and times-three receiver local-oscillator multiplication factor. Five crystals permit reception of 25 channels from 146.34 to 147.06 MHz.

	$F_1 = 5F_E$	$F_2 = 5F_D$	$F_3 = 5F_C$	$F_4 = 5F_B$	$F_5 = 5F_A$
	56.7667	56.7167	56.6667	56.6167	56.5667
$F_A = 11.3133$	147.06	146.91	146.76	146.61	146.46
$F_B = 11.3233$	147.03	146.88	146.73	146.58	146.43
$F_C = 11.3333$	147.00	146.85	146.70	146.55	146.40
$F_D = 11.3433$	146.97	146.82	146.67	146.52	146.37
$F_E = 11.3533$	146.94	146.79	146.64	146.49	146.34

repeater offset (usually 600 kHz). For the normal 600-kHz offset and a 10.7-MHz i-f, the frequency would be

$$F = \frac{10.7 - 0.6}{3} = 3.3667 \text{ MHz}$$

For simplex operation $F_{ro} = 0$ and $F = 10.7/3 = 3.5667$ MHz. Switching could be tied to the *repeat simplex* switch shown in figs. 2 and 3.

For the 34/94 situation, the synthesizer output of $6.0975 \times 8 = 48.78$ MHz, which, when mixed with 3.3667 MHz, yields a difference frequency of 45.4133 MHz. Multiplying this three times in the receiver results in the desired local oscillator frequency of 136.24 MHz which is 10.7 MHz below 146.94. The 45-MHz filter is necessary to eliminate the *sum* of

the frequencies being mixed in the circuit.

A slight modification of the matrix synthesizer described above can be used to generate local-oscillator frequencies for an all-channel receiver (see fig. 6). This technique lends itself to automatic scanning using a 5x5 matrix sequenced by two 5-bit shift registers.

Here, a 5x5 matrix is possible which generates local-oscillator frequencies for 25 receive channels from 146.34 to 147.06 MHz with only five crystals. Because the desired frequencies (to substitute for the receiver's first local-oscillator crystals) are higher in the receiver case, it becomes convenient to *multiply* the synthesizer crystal fundamental frequencies rather than to divide, as in the case of the transmitter synthesizer. The crystal formula is

$$F_1 - F_A = \frac{\text{highest frequency} - \text{receiver i-f}}{\text{receiver multiplier}} \quad (4)$$

but F_1 is the 5th harmonic of F_E , which must be 0.04 MHz higher than F_A for proper channel spacing (by the same reasoning used in the transmitter version) so $F_1 = 5F_E = 5(F_A + 0.04)$. Substituting in the above equation

$$F_A = 5(F_A + 0.04) - F_A$$

$$= \frac{147.06 - 10.7}{3} = 11.3135 \text{ MHz}$$

Other frequencies in the 5x5 receiver matrix are shown in table 2.

Here again, precautions must be taken

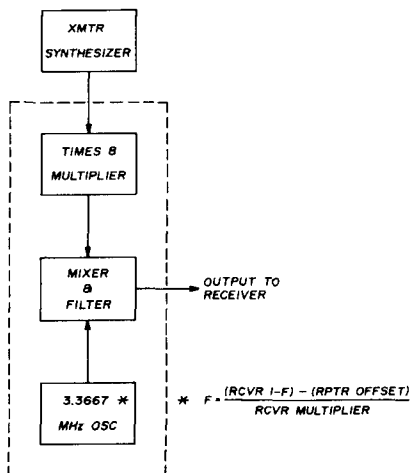


fig. 5. Tracking receiver local-oscillator frequencies can be obtained for repeater operation using this circuit. If reception is required on normal repeater input channels, 3.5667 MHz is substituted for the 3.3667 MHz frequency shown.

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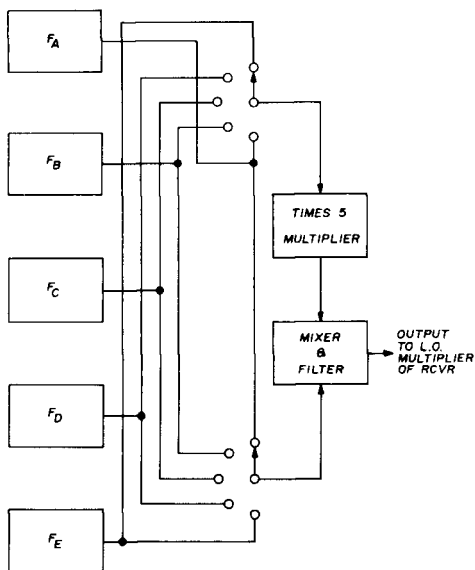


fig. 6. Suggested 5-crystal, 25-channel receiver local-oscillator synthesizer covering 146.70 through 146.34 MHz in 30-kHz steps. See table 2 for frequencies and crystal frequencies.

to minimize birdies and other spurious signals. For example, assume F_A and F_1 are being mixed to obtain the proper local-oscillator frequency to receive 147.06 MHz $(56.7665 - 11.3113)/3 = 136.3896$ MHz. It will be noticed that the 12th harmonic of 11.3133 MHz is 135.7596, which, if present in the receiver mixer, will admit a strong signal on 146.46. So, good filtering and isolation are important in designing a receiver around this matrix.

Although 10.7-MHz intermediate frequencies have been used as examples in this article, versions are possible for surplus equipment. Naturally, attention will have to be given to matching the outputs of these circuits to the requirements of the equipment to be used, but more difficult problems have been solved by ham ingenuity before and they should be solvable in this instance.

It is hoped that this idea article will inspire some interesting construction projects and promote more flexible and economical two-meter fm operation in general.

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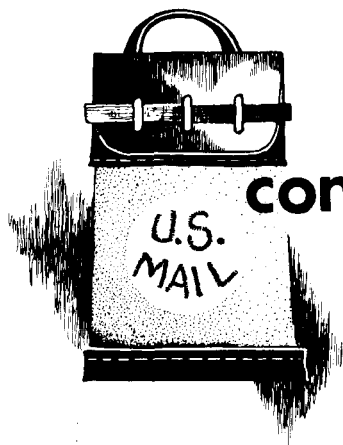


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comments

speech clipping

Dear HR:

I wish to make a few comments on G6XN's article on speech clipping. He states, "the clipping level should be sharply defined," but does not give a reason for this. Any nonlinearity in a system creates distortion and rounded corners on the envelope would create a low order product, increasing the possibility of the product falling within the passband. An audio or rf compressor should precede the clipper to keep the clipping level constant as normal speech inflections (and emphasis on certain syllables) amount to 10 or 15 dB. How you can keep the clipping level constant without one is beyond me.

G6XN discusses filter shape characteristics rather thoroughly, but fails to mention that the second filter must have linear *phase* characteristics. Recall that a triangular wave (which has a lower peak to average than a sine wave) has the same harmonic content as the square wave we went to all the trouble to produce; you might even decide to use a maximally linear phase characteristic in the filter despite its lack of steep skirts.

I haven't tried it, but I think there would be more in-band distortion if anyone tried to use two-stage clipping with a third filter between the two filter stages. The reason for this is that the input to the second filter contains in-band distortion products created by the first clipper.

Mr. Moxon went through a lot of detail explaining why anything not essential should not be allowed to enter the clipper stage. This brings to mind an interesting possibility. Most speech information is contained in three ranges: 300-750 Hz, 1250-1750 Hz and 2250-2750 Hz (Technical Correspondance, *QST*, December, 1960). While the original article claims 10-dB improvement, I believe this to be for the receiving case as there is not that much speech power in the ranges 750-1250 Hz and 1750-2250 Hz.

With rf clipping it might be advantageous to build a three-band audio filter as the system is already rather complex and the filter system would not increase the complexity that much more. However, this must be tried as the results would be hard to analyze by analytical reasoning, as are most electronic systems involving the speech waveform. Anyone trying this should remember, however, that there should be provisions for switching the filters out if slow-scan tv operation is contemplated.

Larry Tessari, WA8ASD
Taylor, Michigan

In regard to the first paragraph, there seems to be some confusion between clipping level which is fixed by, for example, the bias on a diode, and the amount of clipping which is the number of dB by which speech peaks exceed this bias level.

It is important for the clipping level to be clearly defined for the reason given on page 33 of my article. Any uncertainty about the peak level means that the drive to the final must be reduced by an amount equal to the uncertainty, since otherwise you cannot be sure of not overdriving the stage. On the other hand, my fig. 1 shows that the amount of clipping can vary between 15 and 25 dB for a little over 1-dB change in average signal level, so there is no need to keep this amount particularly constant.

Nonlinearity is, of course, inseparable from clipping, but the experimental evidence is that any potentially harmful distortion is submerged under the wanted signal. Distortion is intermodulation not harmonic, and as those who have measured it say it is at least 10 dB down, it should amount to no more than a slight increase of background noise. The rounding of corners of the speech envelope is likely to be a function of the filter characteristic rather than the clipper. I have not found it necessary to use a compressor in front of the clipper but this would no doubt be an advantage to operators less used to speaking at a constant level.

It is an interesting question, however, as to what proportion of the statistical variations normally attributed to speech waveforms are inherent in the nature of speech and how much to inflections, emphasis, etc., occurring slowly enough to be taken care of by a compressor. This must obviously depend a lot on the individual.

Mr. Tessari raises an interesting point about the phase characteristics. I imagine the most serious consequence of a non-

-linear phase characteristic would be to delay high and low frequencies by different amounts, leading to amplitude variations at the output of the filter when both are present simultaneously. This could cause a system setup on i-f tones to go "over the top" occasionally on speech. I have not noticed this in practice but will have a more careful look for it.

It had not occurred to me to use a third filter between the two clipping circuits, and I would certainly agree that it would not be a good idea.

The 3-range idea is quite an old one, but my impression is that any restriction of bandwidth below that of an ordinary ssb filter produces a result which is not easy to listen to. This can be checked with a band-stop filter such as is sometimes used for removing CW interference. Rf clipping owes part of its effectiveness to boosting low-energy signals (if they occur in isolation) and this must presumably tend to fill in the 750-1250 Hz and 1750-2250 Hz gaps. I would agree, however, that it is not really possible to be analytical, and there are still plenty of unknowns in this field.

Leslie A. Moxon, G6XN

Dear HR:

I found the article by G6XN on the performance of rf speech clippers in the November, 1972, issue of *ham radio* to be quite informative and interesting. On page 33 the author refers to the question of acceptable passband ripple being halved by a two-filter system. I would like to point out that, based upon laboratory measurements, the passband ripple is actually *reduced* in relation to the amount of clipping, since it fills the valleys by nature of its basic process.

Typical current production filters, such as the Collins, etc., exhibit passband ripple in the area of a maximum 1.5 dB. More typically, in many that I have tested, they measure less than 1 dB.

Therefore, in rf clipping, with the conventional two-filter system, using well

matched filters for shape and impedance, no system degradation will be audible from the use of standard filters. This is confirmed by my own use of such a system for some time.

Marv Gonsior, W6VFR
Fullerton, California

rf speech clipping

Dear HR:

I read with great interest the paper on rf speech clipping by G6XN in the November, 1972, issue of *ham radio*. It is the best article I have read on the subject, and is a most informative and timely work.

I note that Mr. Moxon, on page 32, calls the theory behind pre-emphasis before speech clipping "obscure." On the contrary, I feel that it is quite straightforward as it applies to audio-frequency clipping.

One disadvantage of audio clipping, as compared to rf clipping, is that it generates in-band distortion products. These occur at odd-numbered multiples of the frequency of the clipped tone. For example, clipping a 100-Hz tone generates distortion products at 300, 500 and 700 Hz, etc.

In audio clipping, distortion products at 2500 Hz and higher are removed by a steep-skirted low-pass filter following the clipping stage. However, the distortion products of the lower frequencies are retained in the audio signal. These products are generated by the clipping of a tone below about 800 Hz. By minimizing the power in speech tones below 800 Hz, you can minimize the power of the in-band distortion products.

Unfortunately, however, much of the power density in normal speech is concentrated below 500 Hz, the most damaging region. In addition, these tones contribute little to communications intelligence. Therefore, they are best removed or attenuated before audio clipping.

Author OH2CD very effectively uses pre-emphasis in the clipper described in the February, 1972, issue of *ham radio*. In fact, he uses 12-dB per octave roll-off below 1400 Hz, and 18-dB per octave roll-off below 300 Hz.

The argument concerning distortion products does not apply to rf clipping, but pre-emphasis may nonetheless be useful since energy in speech tones below 500 Hz contributes little to communications intelligence while consuming considerable amounts of transmitter power.

Tom Ashley, WB4SIJ
Lexington, Kentucky

technical education

Dear HR:

I read with interest "A Second Look" in the January, 1973, issue of *ham radio*. Your observations on the trend in technical education are, in my opinion, accurate and timely. The collegiate level engineering studies have indeed reached a degree of sophistication that renders the graduate incapable of performing at the job site. These institutions, in striving for academic excellence, have failed to establish priorities relative to the actual industrial needs.

The real need in our field today is, as you stated, a "gut" understanding of electronics rather than mathematical sophistication. An alternative that you did not mention (and one that could perhaps contribute to a future article) is the practical and applied curricula offered by the many career training institutes around the country. These schools stick to the "gut" material and supply a large portion of the qualified technical personnel now being used. An excellent source of information is the National Association of Trade and Technical Schools, 2021 L Street, NW, Washington, D.C.; William A. Goddard, Executive Director.

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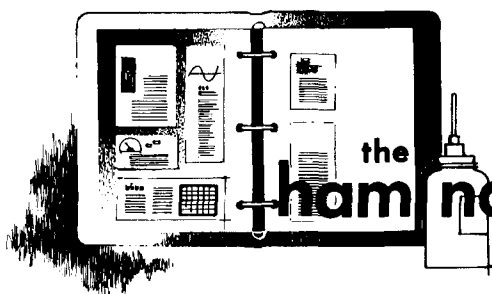
*The Hams at Heath/Schlumberger: Chas, W8IAI; Tom, W8JAN; Norm, W8EEF; Jerry, K8KHS; Bob, K9EQB/8; Bill, K7IRC/8; Mike, WB8CDU; Owen, K3S JL/8; Lee, WA8PHL.

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the ham notebook

sideband location

Frequently, you can find 30 to 50 upper-sideband stations in one day, operating within one kHz of 14349 or 21449 kHz, thus with the sideband extending over the band edge. This is contrary to FCC regulations, Section 97.63. In addition, Section 97.75 requires independent means for measuring the carrier frequencies, accurate enough to ensure keeping within the band. A bit of listening discloses the fact that many amateurs are uninformed, or are unwilling to comply.

Fig. 1 is an approximation of the situation in the Collins 32S-3 exciter. The carrier is off to one side so that it is suppressed 30 dB because of that, and another 20 dB or so in the balanced modulator. Using only the instruction manual information, not supported by measurements, you will note that the 2100-Hz filter width, 6 dB down, actually extends more than 2100 Hz above the carrier frequency because of the position of the carrier down on the side of the filter curve. At 30 dB down, the voice extends 2700 Hz above the carrier frequency.

In the Swan 500, fig. 2, even at 6 dB down, the modulation extends more than 2700 Hz higher in frequency. At 20 dB down, the voice extends to 3500 Hz above the carrier. At 60 dB down, the filter width is given as 4400 Hz, but the published curve is about 5 kHz wide there, of which about 1 kHz is below the carrier and some 4 kHz is above.

Filters may not all be as symmetrical as these. Some difference in the shape on one or the other side of the curve may be found.

Not many amateurs appreciate that the military and commercial frequency assignments are for the *midpoint* of the emission, *not* the suppressed carrier frequency which is widely used in amateur

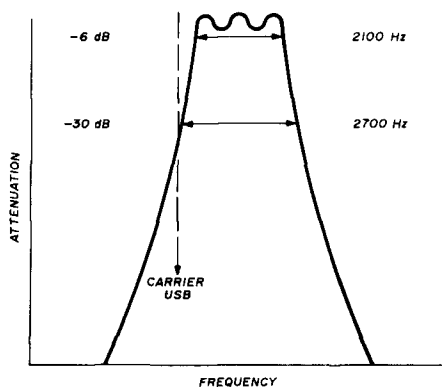


fig. 1. Bandwidths for Collins 32S-3 exciter in the USB mode.

radio. As a result, a MARS transmission in USB on a dial setting of 20998 kHz normally will extend appreciably into the bottom of the 15-meter band.

In order to keep the MARS stations on the right frequency, Navy-Marine Corps MARS has published fig. 3 in their instructions, DNC 8 (A). This is somewhat simplified, in that it does not stress the separation of the suppressed carrier from the modulation, nor any level of attenuation at the edges of the modulation. The illustration shows a presumed 3-kHz voice channel extending up from

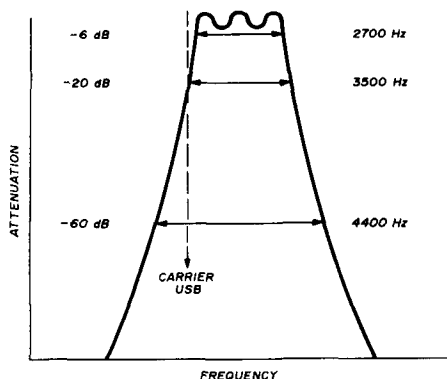


fig. 2. Bandwidths for Swan 500 transceiver in the USB mode.

the suppressed carrier. Therefore, you must set the exciter's suppressed carrier 1.5 kHz *below* the assigned frequency for USB transmission. As will be seen from fig. 2, some equipment would not keep within a 3 kHz channel unless you could accept perhaps only 12 dB attenuation outside of the channel; and the optimum detuning of the suppressed carrier would be slightly different.

From the illustrations it can be seen that fairly reasonable attenuation results when the Collins 32S-3 is operated in USB mode 3 kHz inside of the upper band edge, whereas the Swan 500 should stay inside by at least 4 kHz, and then only with suitable calibration equipment to ensure accuracy of the frequency measurement. A linear amplifier will raise the level of the emission and, therefore, of the filter curve, thus inviting greater interference to adjacent channels.

Minimum power is required by the Communication Act, Section 324, now written into the Amateur rules, Section 97.67 (b), as quoted in the October, 1972, issue of *QST*, page 108. Unnecessary

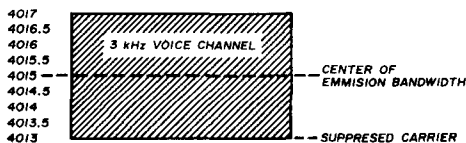


fig. 3. Example of emission published in Navy-Marine Corps MARS Communication Instructions, DNC 8 (A).

power may create considerable unnecessary splatter due to the filter skirts, equipment problems or nonlinearity in the several stages following the ssb filter and on through the linear amplifier. In addition, there may be off-frequency emissions greater than those indicated by the filter skirts demonstrated by the above tests. Furthermore, the transmitter can have a somewhat different filter performance than the receiver.

Bill Conklin, K6KA

swr bridge readings

When you can't obtain full-scale deflection on your swr bridge because of low power output or low antenna impedance, you may still determine the swr with fair accuracy by using the half-scale values listed in table 1.

table 1. Typical swr values when swr bridge is adjusted for half-scale deflection on forward power instead of full-scale deflection. This may be the case if power output is low or the output frequency is high.

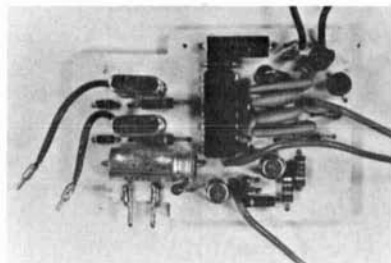
half-scale swr reading	actual swr
1.1	1.2
1.2	1.3
1.3	1.5
1.4	1.7
1.5	2.0
1.75	3.0
2.0	3.5
2.5	4.0
3.0	Infinite

The swr bridge is calibrated in terms of half-scale forward meter deflection instead of full scale deflection. First, adjust the bridge for full-scale deflection in the forward direction. Produce a high swr reading (3:1 or 4:1) by detuning the antenna coupler or by any other convenient means. Now, reduce the forward reading to half scale and note the swr reading. Repeat the above steps until you have tabulated a complete set of swr readings as shown in table 1.

F.J. Bauer, W6FPO

new products

vhf fm scanner



Topeka Engineering has just announced a two-channel frequency scanner for the Regency HR2 and HR2A transceivers, the *Scan 2*. The unit plugs into the HR2 with only three solder connections and one component change. The scanner unit mounts internally above the A, B and C crystal sockets. Scanning is accomplished by inserting the desired crystals into positions A and B. A and B channels will then be scanned when the switch is in position C so no change is required to the radio.

A unique search-back feature of the *Scan 2* allows the unit to scan a channel not in use every 5 seconds; this may be disabled or switched in or out. The scan rate is 20 times per second when no channel is in use. The *Scan 2* is available at \$19.95 including shipping from Topeka FM Communications and Electronics, 1313 East 18th Terrace, Topeka, Kansas 66607. For more information, use *check-off* on page 94.

midland enters amateur radio market



Midland Electronics Company, a leader in communications equipment for over a decade, has entered the amateur radio field. Leading off Midland's amateur radio offerings is a 15-watt, 12-channel, 2-meter fm mobile transceiver. This is a compact unit, 2-1/4" high by 6-3/8" wide by 8-7/8" deep, weighing only 4-1/2 pounds. It provides 15 watts rf output (1 watt in the low-power position) and contains a multiple fet front end receiver with high-Q helical resonator filters and ceramic filters. The model 13-500 operates on 12 volts dc and is supplied with push-to-talk microphone, mobile-mounting bracket and crystals for 16/76, 34/94 and 94/94. Suggested retail price is \$249.95. Additional crystals covering the full 2-meter range are available from Midland.

Midland's 10-watt, 12-channel 220 fm unit brings a much-wanted, low-cost mobile transceiver to this growing amateur band. The model 13-509 transmits at 10 watts or 1 watt rf output, and has the same compact size and light weight of the two-meter mobile equipment. Features and equipment are similar throughout and 223.00 simplex crystals are supplied. Suggested retail price is \$219.95.

All of these new Midland amateur radio transceivers are described fully in a colorful new catalog. For a free copy of this catalog or information on Midland's amateur radio dealer franchise program, contact the Midland Sales Manager, Midland Electronics Company, Box 19032, Kansas City, Missouri 64141, telephone (816) 474-5080, or use *check-off* on page 94.

electronic keyer



A super low-power electronic keyer using complementary MOS (C-MOS) integrated circuits has been announced by Curtis Electro Devices. For QRP in the field or the full gallon at home, the EK-420 C-MOS Deluxe Keyer offers effortless, self-completing dots, dashes and spaces, dot memory, iambic operation, built-in side-tone and 4-inch speaker, built-in power supply and a reed relay for grid-block keying or solid-state rigs. It operates on 115 Vac or +4.5 to +14 Vdc.

Because of C-MOS circuitry, the EK-420 consumes only $\frac{1}{2}$ mW during stand-by. When keying, power consumption rises to 180 mW. This allows extended operation on an inexpensive snap-in 9-volt transistor battery. A rear-panel accessory socket allows instant connection of a soon-to-be-announced four program, 2048-bit (200-character) memory unit.

Front-panel controls include sidetone volume and pitch, weight and speed, tune, self-test, and ac-battery selector switch. All eight ICs, three transistors and the reed relay plug in to allow easy field service.

Housed in a heavy gauge case, the EK-420 is priced at \$139.95 complete. For more information contact Curtis Electro Devices, Inc., Box 4090, Mountain View, California 94040, or use *check-off* on page 94.

mobile antenna mount

The new Larsen Electronics mobile antenna mount, described in the June, 1973, issue of *ham radio*, is designed for the usual 3/4-inch hole, *not* a 3-inch hole. The mount is available from Larsen Electronics, Inc., Box 1686, Vancouver, Washington 98663.

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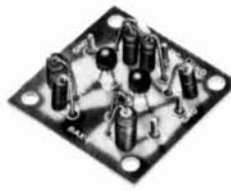
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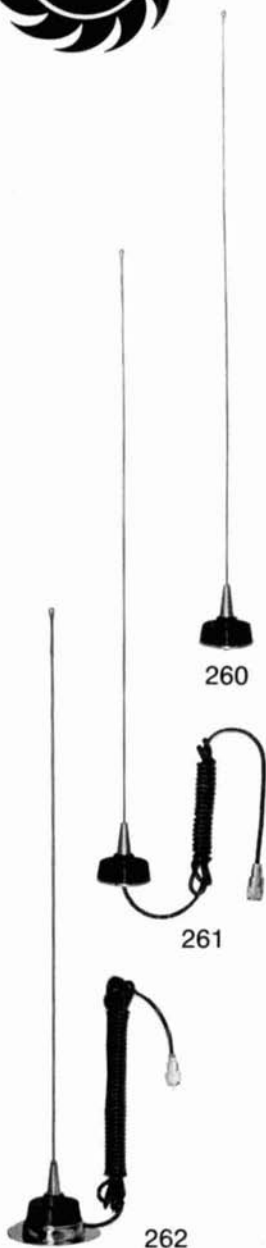
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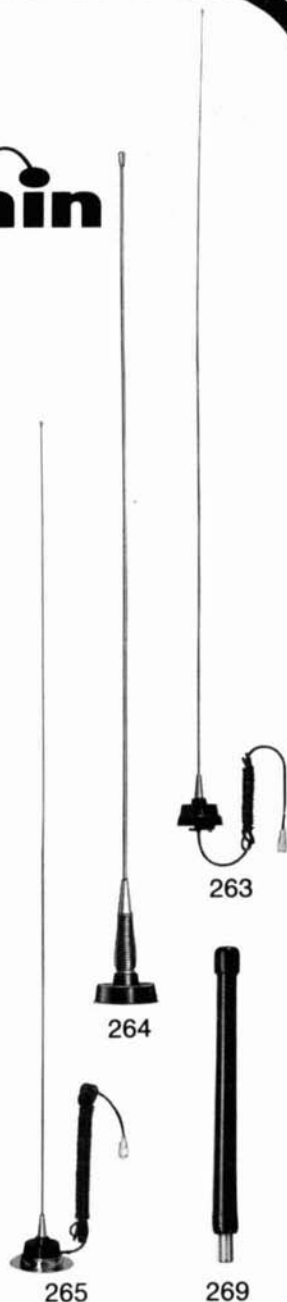
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<p>TRIAC 2N6344 600V DA TO-220 \$1.00</p> <p>LED FL 100 special !!!! each \$1.30 (Ham Radio Specials!) ten or more—20.00</p> <p>each \$1.30 (Ham Radio Specials!) ten or more—20.00</p> <p>all IC's are new and fully tested, leads are plated with gold or solder. Orders for \$5 or more will be shipped prepaid. Add 35¢ for smaller orders. California residents add sales tax. IC orders are shipped with 24 hrs. COD's may be phoned in 310. minimum money back guarantee. P.O. Box 3 Carmichael California 95608</p> <p>BABYLON ELECTRONICS (916) 966-2111</p>	<p>LINEARS</p> <table border="1"> <tr><td>LM100</td><td>.....</td><td>\$1.00</td></tr> <tr><td>LM309H</td><td>.....</td><td>.75</td></tr> <tr><td>LM309K</td><td>.....</td><td>2.00</td></tr> <tr><td>NE5556</td><td>.....</td><td>1.00</td></tr> <tr><td>NE560</td><td>.....</td><td>3.25</td></tr> <tr><td>741(MINI DIP)</td><td>.....</td><td>.45</td></tr> <tr><td>747</td><td>.....</td><td>1.10</td></tr> <tr><td>709</td><td>.....</td><td>.45</td></tr> <tr><td>710</td><td>.....</td><td>.40</td></tr> <tr><td>711</td><td>.....</td><td>.40</td></tr> <tr><td>723</td><td>.....</td><td>1.00</td></tr> <tr><td>LM380(audio amp)</td><td>.....</td><td>1.75</td></tr> </table> <p>CMOS</p> <table border="1"> <tr><td>CD4001</td><td>.....</td><td>\$.75</td></tr> <tr><td>CD4002</td><td>.....</td><td>.75</td></tr> <tr><td>74C00</td><td>.....</td><td>.75</td></tr> <tr><td>CD4012</td><td>.....</td><td>.75</td></tr> <tr><td>CD4023</td><td>.....</td><td>.75</td></tr> </table>	LM100	\$1.00	LM309H75	LM309K	2.00	NE5556	1.00	NE560	3.25	741(MINI DIP)45	747	1.10	70945	71040	71140	723	1.00	LM380(audio amp)	1.75	CD4001	\$.75	CD400275	74C0075	CD401275	CD402375																																																																
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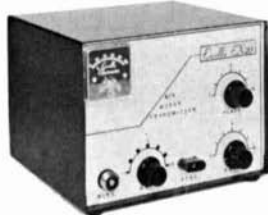
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80M THROUGH 10M
1200W PEP



The SP101-P Landliner provides phone patch operation as well as speaker. Front panel: Patch switch, meter, TX and RX gain controls. Rear apron: Receiver 4 ohm output, receiver 600 ohm output, monitor null switch, balance control, line jack, transmitter high Z jack.

The FV-101 permits split frequency operation and control from either the FT-101 or FTDX401.

The FT-101 exciter covers 160, 80, 40, 20, 15, (CB), and 10 meters and comes complete with microphone cable and plug, fused DC power cable and plug. AC cable with plugs and all necessary plugs are furnished. AC and DC supplies are internal.

The FL-2100 linear amplifier needs only 3 wire cable and coax cable. Connectors are furnished.

FTDX401 \$599.00
TRANSCVR 560W PEP

FV401 \$99.00
EXTERNAL VFO
80M THROUGH 10M

FL2000B \$399.00
LINEAR AMP
1200W PEP

FRDX400 \$299.00
RECEIVER
160M THROUGH 10M



The FTdx401 features high power, super sensitivity and sharp selectivity. The FT-dx401 includes: AC power supply, noise blanker, 100 KC and 25 KC calibrators. VOX break-in, phone patch terminal, cooling fan. Covers 3.5 through 10 MHz plus WWV. 560 watts PEP. All that is required to get on the air is a microphone and speaker.

The FV-401 permits split frequency operation for the DX chaser or net operator. Covers 80 through 10 meters.

FL 2000 B 1200 watts PEP, 1000 watts CW, 600 watts AM. Drive power required 100 watts. Has two cooling fans and uses two 572 B tubes.

FRdx400 includes 2 mechanical filters plus "T" notch rejection tuning, and clarifier for easy zero set for SSB. Crystal control 1st mixer and tunable 1st I.F. provides stable operation and high spurious rejection. 100 KC and 25 KC calibrators. VFO can be used in transceive operation in conjunction with F series transmitter.

FLdx400 operates SSB, (USB LSB selectable), AM, CW and FSK. Circuitry can be built in for RTTY operation. 240 watts PEP. VOX, PTT, and break-in CW.

FL 2000B grounded grid linear uses a pair of 572 B tubes. Plate meter VSWR monitor, 2 fans, built-in power supply, 80 through 10 meters, 1200 watts PEP with distortion product in excess of 30 DB down.

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EXCITER
80M THROUGH 10M

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1200W PEP

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SPEAKER/PATCH

FP-2
AC POWER SUPPLY



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Complete with
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D.C. Power Cord 6 Ft.
Signal Test Lead with
BNC Connector 3 Ft.

FP-2 AC power supply specifications: Output - 13.5 volts, 2 amps. AC input - 100/117/220/234 volts. Speaker - 5" x 3 1/2". Portable or home base operation can be achieved with the addition of the optional FP-2 power pack. This AC power pack provides regulated DC power for the transceiver and charging voltage for optional leak proof rechargeable colloidal type batteries. In addition, a high fidelity elliptical style speaker is built into the pack.

The FT-2FB opens the door to noise free broadcast quality 2 meter operation, and thanks to the repeater stations throughout the country, the 2 meter band is no longer restricted to line of sight. General coverage 144 to 148 MHz, 12 channels (3 supplied). Push to talk. Receiver .3 amps, transmit 1.7 amps, power source 13.5 volts ± 10%. Dimensions 6-3/8" w. x 2-1/2" h. x 10" d., weight 4 lbs. Comes with dynamic microphone, connector plug, DC cord, fuse and mobile mount.

The FT-2 auto is a compact base or mobile VHF/FM transceiver, covering 146 to 148 MHz, featuring electronic scanning up to 8 stations between 146-148 MHz with priority channel sampling while locked on another channel. Adjustable tone burst push-button lock on for repeater actuation. The FT-2 auto is self-contained. Two power cables are supplied with the transceiver, including all mounting hardware, cables, connectors, and accessories required for both mobile and base installation, as well as dynamic push to talk microphone. Operates from various AC voltages or 13.5 DC. Dimensions 8-3/4" w. x 4-1/4" h. x 11-5/8" d. Weight 9 lbs.

SPECIFICATIONS

YC-355D		YC-355D		YC-355D	
Frequency range	5Hz to 35MHz (50Hz to 200MHz)	MAX Input Voltage	60V p.p. less than 10 sec (5V p.p.)	Weight	220(W) X 80(H) X 70(D) (8 3/4 W X 3 3/4 H 10 1/2 inches)
Accuracy	± time base stability - 1 count	Input Impedance	HIGH 1 M ohm Low 50 ohms	Tube	Display tube
Display	5 Digit	Input Capacity	Less than 20pF	Semiconductors	Silicon diode
Sampling time	1 multi sec. or 1 sec	Time base Frequency	1 MHz Crystal controlled		Silicon transistor
Display time	0.1 sec - 2 sec	Stability	0.0025% at 0° - 40° C		FET
Frequency Unit	KHz MHz	Power Requirements	100/110/117/200/220/234V 50/60Hz 18V A		IC
Display	Display tube		12-14.5V 1A		
Input Voltage	20mV - 20V p (0.15V - 5V p.p.)				

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URC-11 \$15 each or 3 for \$40.00



7 SEGMENT LED



Hobby craft due to being factory rejects. Most have a segment or decimal inoperative. Still a great "buy" for the experimenter. What an unusual tie clip you can make with pocket battery . . . demo displays, etc. In many applications you don't need full 7 segments. \$1.00 each or \$10 the dozen. 0.333 inches high character.

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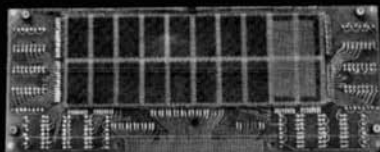
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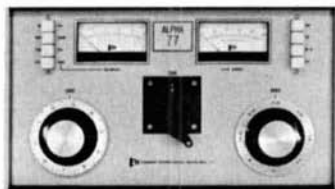
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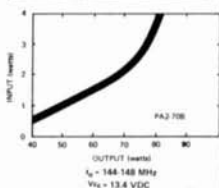
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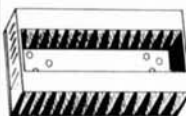
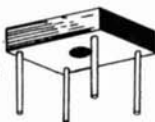
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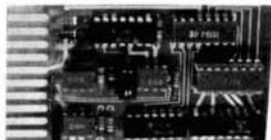
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THE CHICAGO AMATEUR RADIO CLUB announces its 4th annual Hamfest & Mini Auction on September 30th 1973. Time: 2 p.m. till last deal made, at St. Viator's School parking lot, 3606 N. Kedvale, N-W corner of Addison St. Swaps, prizes, refreshments. Donation at gate \$1.50 or for advance \$1.00 tickets contact: Don De Jong, W9KJL, 6158 W. Grand Ave., Chicago, Ill. 60639, Ph. 889-0329 or Kl. 5-3622; George Spockko, WA9JEZ, 5631 W. Irving Pk. Rd., Chicago, Ill. 60634.

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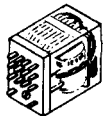
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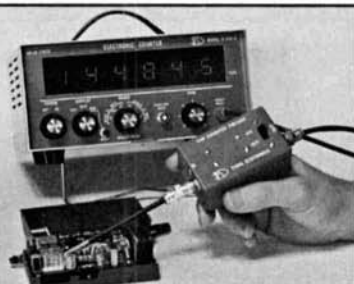
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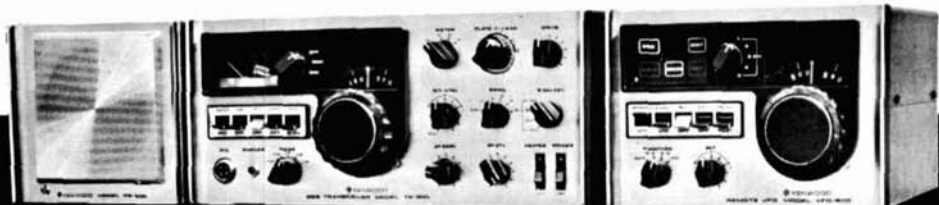
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TS-900

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